Draft

Diamond Head Technical Memorandum: Metals Occurrence in Soils and Groundwater at Diamond Head Site and Surrounding Areas

Prepared for:

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Acronyms and Abbreviations

µg/L	micrograms per liter
BFO-N	Bureau of Field Operations - Northern
ft bgs	feet below ground surface
gpm	gallons per minute
DHS	Diamond Head Oil Superfund Site in Kearny, Hudson County, New Jersey
DOT	Department of Transportation
KCS	Known Contaminated Sites
MCL	maximum contaminant level
MSLA	Municipal Sanitary Landfill Authority
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJIGWSSL	New Jersey Impact to Groundwater Soil Screening Levels
NJNRDCRS	New Jersey Non-Residential Direct Contact Remediation Standards
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information Service
OPRA	Open Public Records Act
OU	operable unit
TAL	target analyte list
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

SECTION 1

Introduction

Purpose

The purpose of this technical memorandum (TM) is to compare metal concentrations in soil and groundwater at the Diamond Head Site (DHS) to metal concentrations in:

- Soils and groundwater at other known contaminated sites in the vicinity (less than 0.5 miles) of the DHS,
- Soils regionally in comparably urbanized Hudson, Essex, and Bergen Counties, and
- Regional aquifers (the regional Stratified Drift and Brunswick aquifers) which underlie the fill and overburden materials at the DHS (the fill and overburden materials are referred to as the stratified water bearing unit throughout the rest of this TM).

The objective of this comparison is to provide perspective on the metal concentrations found at the DHS relative to the surrounding areas (Figure 1-1). This TM is prepared for the United States Environmental Protection Agency (USEPA) Region 2 under Task Order TO 0002, UNDER contract No. W912DQ-08-D-0016 with the United States Army Corps of Engineers (USACE).

Approach

This TM is based on the metal concentrations in soils and groundwater measured during the Phase 1 Remedial Investigation (RI) conducted in 2003 (*Final Phase 1 Technical Memorandum,* CH2M HILL 2005) and during the Operable Unit 2 RI conducted in 2009 (*Operable Unit 2 Remedial Investigation Technical Memorandum,* CH2M HILL 2009). The metal results for soils and groundwater from both investigations compared to the most recent standards and criteria can be found in the Phase 1 and Operable Unit 2 Data Summary (CH2M HILL, 2009).

The Phase 1 results indicated that multiple metals exceeded the New Jersey criteria for direct contact with the soils. Therefore, this TM compares the metal concentrations in shallow soils (0-5 feet) at the site to the background metal concentrations expected to occur in shallow soils in the urban environments of Hudson, Essex, and Bergen Counties (or the Urban Piedmont region as stated in the reference report).

The Phase 1 and OU2 RIs indicated that the following metals represented the most significant concerns for groundwater (e.g. exceeded criteria most often, occurred at higher concentrations than other metals): arsenic, lead, iron, manganese, and sodium (CH2M HILL, 2009). Therefore, for the deeper soils and the groundwater, the concentrations for these metals in the soils and groundwater were compared to the following:

- Soil concentrations were compared to the concentrations in soils at surrounding sites known to be contaminated to obtain an understanding of how site conditions compare to the general setting of the area, and
- Groundwater concentrations were compared to the concentrations occurring regionally in the aquifers underlying the stratified water bearing unit at the site to obtain an understanding of whether the groundwater at the site may be contributing contamination to these deeper zones.

In addition, phase and piper diagrams were developed to understand physiochemical conditions and metal behavior in groundwater in the three units that were compared. It should be noted that in addition to these 4 metals, the following metals have also been found above standards / criteria in groundwater beneath the DHS, although the occurrences of exceedances were not as frequent as the above 4 metals: antimony, chromium, nickel, and thallium.

To achieve the above objectives, information was obtained from the following sources:

- New Jersey Department of Environmental Protection (NJDEP) Published Literature Search
- United States Geological Survey (USGS) Database Search
- Open Public Records Act (OPRA) File Review

NJDEP Published Literature Search

Background metals concentrations occurring in urban environments were obtained from the following two NJDEP reports: *"A Summary of Selected Soil Constituents and Contaminants at Background Locations in New Jersey"* (NJDEP, 1993a), and *"Ambient Levels of Metals in New Jersey Soils"* (Sanders, 2003).

The 1993 NJDEP study describes background soils as those soils that have not been impacted by a local-point source, but may contain some contribution from diffuse anthropogenic pollution (NJDEP, 1993a). The study includes eighty background soil samples collected to a depth of twelve inches throughout New Jersey; nineteen of these were collected from urban environments including Kearny.

The 2003 Sanders report includes a summary of the results from three studies conducted by BEM Systems Inc (BEM) between 1996 and 2001. The purpose of these studies was "to gather information to support the development of soil cleanup criteria, which cannot be set below ambient levels". Based on the 2003 Sanders report, ambient levels are defined as "concentrations of contaminants consistently present in the environment in the region of a site and which has not been influenced by localized human activities." A total of 248 samples were collected from a depth of 0-6 inches in the three studies; 67 of these were from the Urban Piedmont region where the DHS is situated.

Soil samples from both studies provided information on metals on USEPA's Target Analyte List (TAL).

USGS Database Search

Groundwater quality data for the area around the DHS was obtained from the United States Geological Survey's (USGS) National Water Information Service (NWIS) database. The data was obtained for the Stratified Drift and the Brunswick aquifer for an area surrounding the site as delimited by latitudes 40°38'00"N and 40°49'00"N, and longitudes 74°02'00"W and 74°12'00"W.

In addition to metals data, water quality information was obtained for the following: field chemistry (pH, specific conductance, Eh, dissolved oxygen, carbon dioxide), major cations (calcium, magnesium, potassium, and sodium), major anions (sulfate, bicarbonate, chloride), and other general water quality constituents (total dissolved solids, total organic carbon, etc.).

OPRA File Review

OPRA file reviews were requested for known contaminated sites (KCS) situated within ½ mile radius of the DHS. These sites were identified on the NJDEP i-MAP database and are shown on Figure 1-2. The reviews were conducted at NJDEP's Bureau of Field Operations - Northern (BFO-N) office in Cedar Knolls, New Jersey and at NJDEP's headquarters in Trenton, New Jersey. The files for thirteen KCS located within ½ mile of the DHS were reviewed. Two of the sites border the DHS (Campbell Foundry and Municipal Sanitary Landfill Authority (MSLA) 1-D Landfill).

Site Description

The DHS is located at 1401 Harrison Avenue, Kearny, New Jersey (Figure 1-1 site location map). It is situated along the eastern margin of the Triassic Lowlands (Piedmont) geomorphic province of northern New Jersey. While in operation the DHS consisted of an oil reprocessing facility with a large oil storage lagoon and multiple aboveground storage tanks (ASTs) and possibly below grade pits used to store oily wastes. These wastes were intermittently discharged directly to adjacent properties to the east and the wetland area on the south side of the site, creating an oil lake. The New Jersey Department of Transportation (NJDOT) acquired part of the property for the construction of I-280 and reportedly removed 10 million gallons of oil and oil-contaminated liquid and 230,000 cubic yards of oily sludge from the oil lagoon. NJDOT also reported that during the I-280 construction, an underground "lake" of oil-contaminated groundwater was found extending from the eastern limits of the I-280 right-of-way to Frank's Creek west of the site. During I-280 construction, the entire oil lagoon was apparently filled, as it no longer appears on post-I-280 construction aerial photographs from 1979. Aerial photographs from 1982 show that the reprocessing infrastructure of the site had also been dismantled.

Geology and Hydrogeology

Thick (greater than 100 ft), unconsolidated sediments underlie the site, including (from oldest to youngest) Pleistocene periglacial deposits, including till and fluvial drift; recent fluvial deposits; and anthropogenic fill. The unconsolidated section is underlain by the Brunswick Group's clastic sedimentary rock units (siltstone, sandstone, shale, and conglomerates) interbedded with Watchung Group (igneous rock) extrusive rocks. Depth to bedrock in the vicinity of the Diamond Head site is estimated to be approximately 120 ft bgs (Nichols, 1968).

This study considers metals in groundwater from the following three water bearing/aquifer units as follows:

- Surficial water bearing unit (includes sands above/below peat at DHS and local sites)
- Stratified Drift Aquifer
- Brunswick Aquifer

Surficial Water Bearing Unit

The shallow subsurface beneath the DHS site and surrounding area consists of anthropogenic fill materials overlying recent sand and peat deposits. The thickness of the fill varies across the site, ranging from not present in scattered locations toward the western side of the site, to 10 ft thick along the eastern side of the site. On the western side of the site, the fill is underlain by a 5-ft-thick sand unit that pinches out across the site until it is not present in borings on the eastern side of the site.

This sand unit is underlain on the western side of the site by a clay unit, and on the eastern side by a silty clay unit, both of which are up to 5 ft thick. A peat layer underlies these units and ranges in thickness from an average of 1 ft up to 3 ft thick, and to an average depth of 15 ft bgs. The unit is considered continuous across the site, although it was less distinct in borings along the western side of the property. Although the hydrostratigraphy of the fill and recent sediments beneath DHS is fairly distinct, for the purpose of comparison with USGS databases in this TM, these materials are grouped as a single unit called the surficial water bearing unit.

Groundwater occurs at approximately 2-feet below grade at DHS, thus most of the anthropogenic and recent alluvial deposits are saturated. Groundwater samples from the RI activities collected at MW-11S and MW-11D for field chemistry constituents (pH, Eh, specific conductivity, temperature, dissolved oxygen), metals, and general water quality parameters indicate groundwater geochemistry is favorable to the migration of most metals in the surficial water bearing unit.

The pH of most groundwater ranged from slightly acidic (6.0 to 6.5) to circum-neutral (6.5 to 7.5). With the exception of several samples (5 of 31), groundwater in the surficial water bearing unit was hypoxic (2.0 mg/L > dissolved oxygen (DO) > 1.0 mg/L) to anoxic (1.0 mg/L> DO). Oxidation-reduction (Eh) values ranged less than 100 millivolts (mv) indicating relatively reducing conditions consistent with hypoxic/anoxic groundwater.

Examination of important oxidation/reduction indicator constituents (DO, nitrate/nitrite, iron, manganese, sulfate, and methane) suggests reduction through DO consumption, denitrification and metabolic iron/manganese reducing conditions. Samples from MW-11S/D exhibit elevated sulfate and methane concentrations suggesting mixing of groundwater from discrete zones in the wellbore as sulfate reduction (no sulfate) should occur before methanogenesis (elevated methane).

Groundwater at MW-11S/11D exhibits elevated concentrations of total organ carbon (TOC), a potential source of reducing conditions and chelation, a potential mechanism for elevating metals concentrations in groundwater. Total phosphorous at MW-11S/11D ranges up to 0.82 mg/L. Phosphate, a component of the total phosphorous analysis, successfully competes with arsenic for available ferric oxyhydroxide sites in the aquifer matrix, potentially elevating arsenic concentrations.

Stratified Drift Aquifer

Recent sediments are underlain by Pleistocene deposits which contain thick sequences of coarse sand and gravel forming a local aquifer (Stratified Drift Aquifer). Beneath DHS, the unconformable contact between the surficial water bearing unit and Stratifed Drift Aquifer lies around 40 feet below grade. The thickness of the Stratified Drift Aquifer reaches 80 feet below DHS. Locally, lateral dimensions, thickness, and aquifer geometry is roughly constrained by the channel of the Passaic River. Thus, the Pleistocene deposits (and Stratifed Drift Aquifer) thin rapidly to the east and west of the river.

For many years, industries in Essex and Hudson Counties withdrew significant volumes of water from the Stratified Drift Aquifer to support processes, and as a source of potable supply. Individual wells produced potable-quality water at several hundred gallons per minute (gpm; Herpers and Barksdale, 1951). This practice ended around the middle of the 20th century as sodium and chloride concentrations gradually increased in individual wells.

Brunswick Aquifer

The Brunswick Formation defines the bedrock basement beneath the study area at around 120 feet below grade beneath DHS. In Hudson and eastern Essex Counties, the Brunswick Formation consists of interbedded fine sandstone, siltstone and shale. Intergranular spaces in these rocks are absent and they exhibit no primary porosity. Groundwater flow occurs in secondary porosity features characterized by fracture-related fabrics including bed-partings, cleavage, joints, and fault zones.

Despite the secondary nature of the porosity, production wells installed in the Brunswick Aquifer appear fairly productive exhibiting pumping rates ranging up to 1,000 gpm, with average rates for properly developed wells around 100 to 200 gpm. Similar to the Stratified Drift Aquifer, wells installed in the Brunswick Aquifer supported local commerce and domestic supply in Essex and Hudson County. Also, wells in the Brunswick Aquifer historically exhibit signs of saltwater intrusion, according to their location in relation to the Passaic River and Newark Bay.

SECTION 2

Results

This section presents the results of the performed evaluations.

Metals in Soils and Groundwater at the DHS

Table 2-1 presents the ranges in metal concentrations in soils at the DHS compared to the following:

- New Jersey Impact to Groundwater Soil Screening Levels (NJIGWSSL) - default values (available at http://www.state.nj.us/dep//srp/guidance/rs/partition_equation.pdf; last revised December 2008)
- New Jersey Non-Residential Direct Contact Remediation Standards (NJNRDCRS) (NJAC 7:26D Appendix 1 Soil Remediation Standards Table)

Above the peat, most of the maximum metal concentrations detected in the soils exceeded the NJIGWSSL; only arsenic, lead, and mercury exceeded the NJNRDCRS. Below the peat, most of the maximum metal concentrations exceeded the NJIGWSSL but only arsenic exceeded the NJNRDCRS.

Table 2-2 presents the ranges in metal concentrations in groundwater at the DHS compared to the following:

- Federal maximum contaminant levels (MCLs) (posted at http://www.epa.gov/safewater/contaminants/index.html as of June 15, 2009) (USEPA 2009)
- New Jersey groundwater quality standards (NJAC 7:9C Appendix 1 Specific Ground Water Quality Criteria) (NJDEP 1993a)

Above the peat, the following metals exceeded both their federal MCL and Class IIA standard: antimony, arsenic, chromium, lead, selenium and thallium. The following metals exceeded only their Class IIA standard: aluminum, iron, manganese, nickel, and sodium. Below the peat, only arsenic exceeded both the federal MCL and the Class IIA standard. The following metals exceeded only their Class IIA standard: aluminum, iron, lead, manganese, selenium, and sodium.

Comparison of Concentrations in Soils and Groundwater at the DHS to Concentrations in Soils and Groundwater at Surrounding Sites

The records for the thirteen KCS listed below were requested to review information on soil and groundwater conditions around the DHS.

RECORD	SITE ID	KNOWN CONTAMINATED SITE	OPRA REQUEST No.	FILE LOCATION
1	7195	AL WILSON CHEMICAL CO	89670	NJDEP BFO-N and Main Office
2	21940	SOS GASES INC	89671	NJDEP Main Office
3	58823	UNITED STATES POSTAL SERVICE PROCESSING CENTER	89673	NJDEP BFO-N
4	67236	BERGEN METAL COMPANY	89675	NJDEP Main Office
5	56730	CENTRAL SALVAGE CO	89677	NJDEP Main Office
6	7196	DREW CHEMICAL CORP	89678	NJDEP Main Office
7	7142	KEARNY SMELTING & REFINING COMPANY	89679	NJDEP Main Office
8	66216	DIAMOND HEAD OIL REFINERY DIVISION	SITE	Not Required
9	105325	TRANSCONTINENTAL GAS PIPELINE VALVE PASSAIC R	89681	NJDEP Main Office
10	7197	B & L OIL CORPORATION	89683	NJDEP Main Office
11	66496	MUNICIPAL SANITARY LANDFILL AUTHORITY (MSLA)	92281	NJDEP Main Office
12	32131	CAMPBELL FOUNDRY CO	89686	NJDEP BFO-N and Main Office
13	66488	KEEGAN LANDFILL	89731	NJDEP Main Office
14	7206	PORT-O-SAN CORP	89732	NJDEP Main Office

Notes:

BFO-N - Bureau of Field Operations - North, located at 7 Ridgedale Ave, Cedar Knolls, NJ

NJDEP Main Office is located at Bldg 401, E. State Street, Trenton, NJ.

File omissions for the following two sites reduced the available information to eleven sites:

- SOS Gases, Inc - the file provided by the NJDEP was actually for the Weldon Asphalt Company. While the Weldon Asphalt Company is situated in the area of interest around the DHS, the file did not contain soil and groundwater data.
- A.L. Wilson - the file did not contain metals data for either soils or groundwater.

Six of the eleven sites had information on metal concentrations in groundwater, all eleven sites had information on metals in soils.

Table 2-3 provides an overview of the available information on metal concentrations in soils and groundwater at each of the reviewed KCS. Of note, the available information was not consistent for constituents across all sites.

Soils

Above the peat, eight of the nine surrounding KCS with available information on arsenic concentrations in soils exhibit ranges in concentrations that were at least one order of magnitude lower than the ranges observed at the DHS. Conversely, B&L Oil Corporation reported significantly higher ranges in arsenic concentrations than found at DHS. Below the peat, only one site had information on arsenic concentrations (Kearny Smelting and Refining Company) and the concentrations were lower than found below the peat at the DHS.

For lead above the peat, eight of the eleven surrounding sites with available information on lead concentrations in soils exhibit ranges in concentrations that were at least one order of magnitude lower than the ranges observed at the DHS. Three of the eleven surrounding sites exhibited ranges in lead concentrations that were comparable to the Diamond Head site. Below the peat, two sites had information on lead concentrations (Kearny Smelting and Refining Company and Keegan). At Kearny Smelting, the range in lead concentrations was one order of magnitude lower than at the DHS; at Keegan, the range of concentrations was two orders of magnitude higher than at the DHS.

Groundwater

Above the peat, four of the six surrounding sites with available information on arsenic concentrations in groundwater exhibit ranges in concentrations that were one order of magnitude lower than the ranges observed at the DHS; the two remaining sites exhibit ranges in concentrations similar to the DHS. Below the peat, only two sites had information on arsenic concentrations (Kearny Smelting and Refining Company and MSLA). At Kearny Smelting, the range in arsenic concentrations was one order of magnitude higher than at the DHS; at MSLA, the range of concentrations was similar to the DHS.

For lead above the peat, five of the seven surrounding sites with available information on lead concentrations in groundwater exhibit ranges in concentrations that were at least one order of magnitude higher than the ranges observed at the DHS. Two of the seven surrounding sites exhibited ranges in lead concentrations that were comparable to the Diamond Head site. Below the peat, two sites had information on lead concentrations (Kearny Smelting and Refining Company and MSLA). At Kearny Smelting, the range in lead concentrations was similar to the DHS; at MSLA, the range of concentrations was two orders of magnitude higher than at the DHS.

Comparison of Concentrations in Soils and Groundwater at the DHS to Background Concentrations

Soils

Table 2-5 presents the ranges of background metal concentrations in soils expected for New Jersey's urban setting based on the 1993 and 2003 studies. Appendix A compares the metal concentrations in soils from the Phase 1 RI to the background concentrations in Table 2-5. Because both the 1993 and 2003 studies are for surficial soils (0-12 inches and 0-6 inches, respectively), the onsite soil data used for the comparison was constrained to depths up to 5 feet. This is because there are few surficial soil samples at the site and with the reworking of the site during the demolition activities and the constructions of I-280, it was assumed that soils up to 5 feet could have been exposed at the surface at one time or another.

All of the DHS sampling locations exceeded the background concentrations for multiple metals including arsenic and lead. The comparison indicated that the concentrations of metals (including arsenic and lead) at the DHS are generally higher than background concentrations in soils expected in urban New Jersey setting.

Groundwater

As previously noted, this evaluation focuses on the following 5 metals: iron, manganese, arsenic, lead and sodium.

Table 2-6 presents the ranges of concentrations at which metals were detected in groundwater at the DHS (above and below the peat, referred collectively as the surficial water bearing unit) and the ranges of corresponding concentrations in the underlying Stratified Drift and Brunswick Aquifers based USGS NWIS database.

Appendix B and C summarize general groundwater quality parameters for the surficial water bearing unit at the DHS (above and below the peat). This information was used to develop piper plots to show the basic chemistry of the water in each of the 3 aquifers and allow comparison between the aquifers (Figure 2-1) as well as equilibrium phase diagrams for the constituents of interest (Figures 2-2 to 2-9). Appendix D contains the USGS water quality data which was used to develop the ranges of metal concentrations in the Stratified Drift and Brunswick Aquifers.

- Concentrations of nearly all metals including arsenic, iron, lead, manganese and sodium appear generally higher in groundwater samples from the surficial zone above the peat then below the peat. In turn, the concentrations of these metals in the surficial water bearing unit appear higher than in the underlying Stratified Drift and Brunswick Aquifers (Tables 2-6). These conditions are expected in urbanized areas underlain by a highly heterogeneous subsurface comprising anthropogenic fill, marsh deposits, and peat beds.

Sodium

- Sodium concentrations in the surficial water bearing unit at DHS range up to 656 mg/L (Table 2-2) exceeding the New Jersey Class IIA groundwater quality standards (NJDEP 1993b). Samples from the surficial water bearing unit, the Stratified Drift Aquifer, and Brunswick Aquifer exhibit sodium as the predominant cation in groundwater with sodium chloride, sodium sulfate, or sodium mixed anion-type waters (Figure 2-1 Piper plots, and Appendix B).
- Elevated sodium concentrations appear consistent with a history of saltwater intrusion in the aquifers beneath the area where the Passaic River enters Newark Bay. Chloride concentrations mapped in a 1951 study (Herpers and Barksdale, 1951) ranged up to 2,000 mg/L just south of DHS, and 500 to 1,000 mg/L beneath the site. Thus, sodium concentrations in groundwater at DHS coincide with local saltwater intrusion identified in 60 year-old study. Areally, chloride (and probably sodium) concentrations subside west of DHS to less than 25 mg/L.

Iron and Manganese

- Iron and manganese concentrations are common trace metals, and frequently reflect natural physiochemical conditions (pH, oxidation-reduction (Eh) potential) in groundwater, rather than anthropogenic activities. Although iron, and to a lesser extent manganese concentrations, appear greatest in the surficial water bearing unit beneath

DHS, concentrations in the Stratified Drift and Brunswick Aquifers also exceed the Class IIA standards (Table 2-6).

- An evaluation of physiochemical conditions at DHS shows elevated iron concentrations consistent with the circum-neutral pH, and relatively reducing groundwater (Figure 2-2 Iron Phase diagram). Equilibrium iron concentrations range up to 56,000 ug/L, slightly less than observed concentrations.
- Elevated iron can arise from the biodegradation of hydrocarbons, but also occurs in marshy, naturally carbon-rich units, like the surficial water bearing unit beneath DHS.
- pH/Eh data was absent for the Stratified Drift Aquifer in the USGS/NWIS database.
- Iron concentrations in samples from the Stratified Drift Aquifer consistently exceeded NJ Class IIA standards.
- Consistent with equilibrium conditions, the Brunswick Aquifer exhibited the lowest iron concentrations of the three aquifer/water bearing units. However, several samples still exceeded the Class IIA standard.
- The strong correlation between actual and equilibrium-predicted concentrations for iron in an aquifer unaffected by anthropogenic contaminants (Brunswick Aquifer) demonstrates that the origin iron is influenced by natural physiochemical conditions. A similar correlation is apparent for the surficial water bearing unit beneath DHS, suggestive of a natural origin for elevated iron concentrations.
- Manganese concentrations exhibited a similar pattern as iron. pH/Eh conditions correlate closely with manganese concentrations in individual samples at DHS (Figure 2-4 Manganese Phase diagram DHS) with equilibrium concentrations ranging over 5,500 ug/L.
- Although data from the Stratified Drift Aquifer was absent, manganese concentrations from samples in the Brunswick Aquifer appeared consistent with physiochemical conditions (Figure 2-5 Manganese Phase diagram Brunswick Aquifer).
- Manganese concentrations in all three units exceeded the Class IIA Standard.
- Similar to iron, the correlation of actual and equilibrium concentrations, and pervasive elevated concentrations in samples from the three aquifer suggests a natural origin for manganese.

Arsenic

- Arsenic concentrations in groundwater samples from the surficial water bearing unit beneath DHS ranged from less than laboratory method detection limits (MDL) to over 160 ug/L (Table 2-4), although many samples exhibited low concentrations between 1 and 5 ug/L.
- With the exception of two samples, equilibrium conditions suggest arsenic occurs as a dissolved arsenate complex in the surficial water bearing unit at the DHS ($H_2AsO_4^-$ or $HAsO_4^-$; Figure 2-6 Arsenic Phase diagram DHS).

- The occurrence of arsenate in comparison to arsenite complexes in the surficial water bearing unit implies distinct behaviors in regard to arsenic solubility, potential mineral precipitation, adsorption, reaction with natural organic materials, and treatment considerations. In addition, arsenate is generally considered less toxic than arsenite to humans and the environment (O'Day et Al, 2007).
- Arsenic concentrations in samples from the Stratified Drift Aquifer ranged from above the MDL to 6.3 ug/L, exceeding the NJ Class IIA standard (Table 2-6).
- Similar to the Stratified Drift Aquifer, arsenic concentrations in samples from the Brunswick Aquifer ranged from above the MDL's to 7 ug/L, exceeding the NJ Class IIA standard (Table 2-6). Studies conducted by NJDEP (Spayd, 2005) have encountered naturally occurring arsenic at concentrations up to 160 ug/L in samples from the Brunswick Aquifer.
- Similar to the surficial water bearing unit beneath DHS, equilibrium relationships indicate arsenic occurs mostly as an arsenate complex in the Brunswick Aquifer (Figure 2-7 Arsenic Phase diagram Brunswick Aquifer)

Lead

- Lead concentrations in groundwater samples from the surficial water bearing unit beneath DHS ranged from less than the MDL to over 350 ug/L, but concentrations from most samples were around the NJ Class IIA standards of 5 ug/L.
- Lead concentrations in groundwater appeared consistent with equilibrium conditions (Figure 2-8 Lead Phase diagram DHS) suggesting lead should occur as a dissolved ion, rather than a precipitated lead oxide mineral in the surficial water bearing unit.
- Lead concentrations in samples from the Stratified Drift Aquifer were less than the MDLs. By comparison, lead concentrations in the Brunswick Aquifer ranged up to 20 ug/L, greater than the NJ Class IIA standard, and Federal MCL.
- Similar to the surficial water bearing unit beneath DHS, physiochemical conditions in groundwater from the Brunswick Aquifer indicated lead occurred as a dissolved ion, rather than an oxide precipitate (Figure 2-9; Lead Phase diagram Brunswick Aquifer).
- Equilibrium conditions in the surficial water bearing unit and Brunswick Aquifer appear favorable for the occurrence of dissolved lead in groundwater.

SECTION 3

Conclusions

The overall conclusions, based on the studies reviewed as part of this evaluation, are as follows:

Soils

- The range of arsenic concentrations in soils above the peat was an order of magnitude higher at the DHS compared to 8 of the 9 surrounding KCS with available data on arsenic. Similarly, the range of lead concentrations in soils above the peat was an order of magnitude higher at the DHS than 8 of the 11 surrounding KCS with available data on lead. Maximum lead concentrations at the remaining 3 sites were comparable to DHS.
- Below the peat, only one site had information on arsenic concentrations and the concentrations were lower than found below the peat at the DHS. For lead below the peat, data was available for two sites. The range in lead concentrations below the peat at the DHS was higher than the range at one of the sites and lower than the range at the other site.
- The concentrations of multiple metals (including arsenic and lead) in shallow soils at the DHS exceeded the concentrations for these metals expected in soils in comparable urban New Jersey setting.
- Based on comparison to available data, while the surrounding KCS and urbanized areas contain metals in soil at elevated concentrations, the concentrations observed at the DHS are generally higher than the comparison sites.

Groundwater

- Groundwater at the reviewed KCS, including DHS, exhibited concentrations of arsenic, iron, manganese, and lead in the surficial water bearing unit above the Class IIA Standards (Table 2-4).
- Concentrations of arsenic in groundwater from the surficial water bearing unit at DHS (above and below the peat) were generally higher or similar to those found at the reviewed KCS. The concentrations of arsenic below the peat at one of the reviewed sites were higher than the concentrations of arsenic at the DHS.
- Concentrations of lead in groundwater from the surficial water bearing unit at DHS (above and below the peat) were generally lower or similar to those found at the reviewed KCS.
- Concentrations of arsenic, iron, lead, and manganese also exceeded the Class IIA standards in the Stratified Drift (except for lead) and Brunswick Aquifers.

- Concentrations of nearly all metals including arsenic, iron, lead, manganese and sodium were generally higher in the surficial water bearing unit at DHS than in the underlying Stratified Drift and Brunswick Aquifers (Tables 2-6). These conditions are expected in urbanized areas underlain by a highly heterogeneous subsurface comprising anthropogenic fill, marsh deposits, and peat beds.
- Maximum arsenic concentrations in the surficial water bearing unit beneath DHS were higher than those in the Stratified Drift and Brunswick Aquifers; as noted, the maximum arsenic concentrations exceeded the Class IIA Standards in all three units.
- Maximum lead concentrations in the surficial water bearing unit beneath DHS were higher than those in the Stratified Drift and Brunswick Aquifers; however, the lead concentrations in the Brunswick Aquifer were higher than in the Stratified Drift Aquifer. As noted, the lead concentrations in the surficial water bearing unit and the Brunswick Aquifer were above the Class IIA standards.
- Equilibrium conditions indicate that lead should occur as a dissolved ion in groundwater samples from the surficial water bearing unit at DHS, and the Brunswick Aquifer rather than an oxide precipitate.
- Equilibrium conditions (with the exception 2 samples) suggest that arsenic occurs as a dissolved arsenate complex in the surfical water bearing unit at DHS and the Brunswick Aquifer. The occurrence of arsenate implies specific mobility behavior for arsenic in groundwater in regard to abiotic and biotic geochemical processes during transport.
- The elevated sodium concentrations at the DHS coincide with historical saltwater intrusion into the subsurface beneath the area surrounding the inlet of the Passaic River to Newark Bay.
- Generally, elevated iron and manganese concentrations from the surficial water bearing unit at DHS and the Brunswick Aquifer appeared consistent with equilibrium conditions established by pH and Eh measurements suggestive of natural conditions.
- Based on review of the available data for the metals of interest in this evaluation, data is suggestive of natural conditions for iron and manganese in the surficial water bearing unit. Lead is observed at concentrations lower than or equal to the surrounding KCS but arsenic is observed at concentrations higher than or equal to the concentrations at the surrounding sites.
- It should be noted that in addition to these 4 metals, the following metals were also found above standards / criteria in groundwater beneath the DHS, although the occurrences of exceedances were not as frequent as the above 4 metals: antimony, chromium, nickel, and thallium.

SECTION 4

References

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Table 2-1. Ranges of Metal Concentrations in Soils at the Diamond Head Site
Diamond Head Oil Superfund Site, Kearny, NJ

Metal	(A) NJIGWSCC (mg/Kg)	(B) NJNRDCRS (mg/Kg)	Soil Concentration Above Peat				Soil Concentration Below Peat			
			Minimum Concentration (mg/Kg)	Validators Flag	Maximum Concentration (mg/Kg)	Validators Flag	Minimum Concentration (mg/Kg)	Validators Flag	Maximum Concentration (mg/Kg)	Validators Flag
Aluminum	3,900		1,260		708,000 [A]	DJ	5,640 [A]		20,100 [A]	J
Antimony	6	450	0.28	J	380 [A]	J	1.1	J	5.6	J
Arsenic	19	19	0.86	J	477 [AB]	J	1.2	J	20.2 [AB]	
Barium	1,300	59,000	14.4	J	7,940 [A]		10	J	182	
Beryllium		140	0.089	J	21.7		0.22	J	0.97	J
Cadmium	1	78	0.062	J	49.3 [A]		0.06	J	3.4 [A]	
Calcium			742		255,000	D	366	J	10,200	J
Chromium			4.8		22,300	J	9		118	
Cobalt	59	590	2	J	315 [A]	J	3.7	J	14.3	
Copper	7,300	45,000	6.1		19,600 [A]	J	4.8	J	222	
Iron			2,890		201,000	J	8,090	J	34,200	J
Lead	59	800	2		37,200 [AB]		2.6		310 [A]	
Magnesium			655		125,000	J	1,680	J	11,200	
Manganese	42	5,900	33.8		2,470 [A]	J	52.6 [A]		732 [A]	J
Mercury	0.1	65	0.06	J	148 [AB]		0.07	J	3.7 [A]	
Nickel	31	23,000	4.3	J	1,560	J	8.7		46.8 [A]	
Potassium			229	J	19,600	J	674	J	3,750	J
Selenium	0.7	5,700	0.69	J	67.4 [A]					
Silver	1	5,700	0.19	J	318 [A]		0.08	J	2 [A]	J
Sodium			38.7	J	13,500	J	161	J	1,030	J
Thallium	3	79	0.18	J	21.3 [A]	J	0.71	J	2.9	J
Vanadium		1,100	4.2	J	6,770		13.3		39.5	
Zinc	600	110,000	21.1	J	63,700 [A]	J	14.7	J	512	J

Notes:
J - Estimated value
DJ - Result is from a dilution and is estimated
[A] - New Jersey Impact to Groundwater Soil Screening Levels (NJIGWSSL) - default values (available at http://www.state.nj.us/dep//srp/guidance/rs/partition_equation.pdf; last revised December 2008)
[B] - New Jersey Non-Residential Direct Contact Remediation Standards (NJNRDCRS) (NJAC 7:26D Appendix 1 Soil Remediation Standards Table)

Soil samples collected at SB-MW-10D, SB-MW-11D, SB-MW-13D and SB-MW-15D below 14 feet were used to determine maximum and minimum concentrations of metal analytes.

Table 2-2. Ranges of Metal Concentrations in Groundwater at the Diamond Head Site
Diamond Head Oil Superfund Site, Kearny, NJ

Metal	(A) Federal MCL (ug/L)	(B) NJ Class IIA Std (ug/L)	Groundwater Concentration Above Peat				Groundwater Concentration Below Peat			
			Minimum Concentration (ug/L)	Validators Flag	Maximum Concentration (ug/L)	Validators Flag	Minimum Concentration (ug/L)	Validators Flag	Maximum Concentration (ug/L)	Validators Flag
Aluminum		200	6.9	J	4,540 [B]		76.5	J	380 [B]	
Antimony	6	6	0.56	J	11.5 [AB]	J	0.64	J	1	J
Arsenic	10	3	2	J	161 [AB]		2.3	J	63.3 [AB]	J
Barium	2,000	6,000	6.8	J	935		30.3	J	381	
Beryllium	4	1	no detects		no detects		0.11	J	0.34	J
Cadmium	5	4	0.11	J	2.9		no detects		no detects	
Calcium			26,900		345,000		43,700		95,700	
Chromium	100	70	3.3	J	3,590 [AB]	J	13.2		27.6	J
Cobalt			0.28	J	11.7	J	1.7	J	6.2	
Copper	1,300	1,300	3.5	J	359		3.8	J	62.8	J
Iron		300	122		32,300 [B]		1,270 [B]		16,800 [B]	
Lead	15	5	0.69	J	353 [AB]		1.2		5 [B]	
Magnesium			9,140		113,000		68,100		134,000	
Manganese		50	2.5		4,520 [B]		121 [B]	J	1,270 [B]	J
Mercury	2	2	0.04	J	0.53		no detects		no detects	
Nickel		100	7.3	J	171 [B]		3.9	J	14.9	J
Potassium			1,660	J	111,000		35,700		52,900	
Selenium	50	40	3.5	J	490 [AB]		23	J	240 [B]	J
Silver			0.11	J	0.11	J	no detects		no detects	
Sodium		50,000	11,200		614,000 [B]	J	263,000 [B]		656,000 [B]	
Thallium	2	2	0.66	J	16.7 [AB]		no detects		no detects	
Vanadium			0.32	J	669		24.8	J	1,950	J
Zinc		2,000	0.78	J	356		16.9	J	22.3	J

Notes:
J - estimated value
[A] - Federal maximum contaminant levels (MCLs) (posted at http://www.epa.gov/safewater/contaminants/index.html as of June 15, 2009) (USEPA 2009)
[B] - New Jersey groundwater quality standards (NJAC 7:9C Appendix 1 Specific Ground Water Quality Criteria)
Includes review of detected concentrations of metals in unfiltered groundwater samples collected at purged wells in 2003 and 2009.

Table 2-3. Summary of Reviewed Known Contaminated Sites Around the DHS
Diamond Head Oil Superfund Site, Kearny, NJ

Site Name	Address	Lead Program	Potential Contamination Sources	Non-Metal		Arsenic		Lead		Other Metals of Concern	Other Metals of Concern
				Soil	GW	Soil	GW	Soil	GW	Soil	Groundwater
Diamond Head Oil Refinery Division	1401 Harrison Ave	BCM	Petroleum products	VOCs, SVOCs, Pesticides and PCBs	VOCs, SVOCs	Yes	Yes	Yes	Yes	Aluminium, antimony, barium, beryllium, cadmium, copper, manganese, mercury and nickel	Aluminum, antimony, chromium, iron, manganese, nickel, sodium and thallium
A.L. Wilson Chemical Co	1050 Harrison Ave	BFO-N	#2 Fuel Oil impacted soils from 3,000-gal UST.	VOCs, TPHs	VOCs	NS	NS	NS	NS	NS	NS
SOS Gases Inc	1100 Harrison Ave	BISR	Information was not available due to NJDEP filing system; files provided included reports on Weldon Asphalt Company.								
United States Postal Service Processing Center	1200 Harrison Ave	BFO-N	Historical fill. Groundwater and surface water bodies; associated contamination source not included in report.	SVOCs, PCBs	VOCs	Yes	Yes	Yes	Yes	Zinc	Copper, zinc and nickel
Bergen Metal Company	Foot of Bergen Ave	SA	Historical fill. Metal waste.	SVOCs, PCBs	NS	NR	NS	Yes	NS	Chromium and zinc	NS
Central Salvage Co	1221 Harrison Ave	BUST	Petroleum contaminated soils beneath gasoline/diesel tank excavation and motor oil/hydraulic oil tank excavations.	BNAs, TPHs	VOCs, Pesticides	No	Yes	Yes	Yes	Cadmium	Chromium, mercury and nickel
Drew Chemical Corp	1106 Harrison Ave	BISR	Chemical manufacturing of water treatment chemicals. Historical fill. No.2 Fuel oil and diesel fuel.	VOCs, SVOCs, DRO, PCBs	VOCs	Yes	NA	Yes	NA	Antimony, beryllium, cadmium, chromium, copper, mercury, nickel, selenium, silver and zinc	NA
Kearny Smelting & Refining Company	936 Harrison Ave	BCM	No 4 Fuel Oil pump leak; light bulb waste with nickel steel for leading -in wires, and nickel plated marine lighting systems. Fill with industrial wastes (ash, slag, cinders, solid manufacturing wastes, building rubble, and construction site rock and soil.	TPHs, PAHs, PCBs	Phenanthrene	Yes	Yes	Yes	Yes	Antimony, beryllium, cadmium, chromium, copper, mercury, nickel, silver and zinc	Nickel
Transcontinental Gas Pipeline Valve Passaic R	Block 284 Lot 18A	BCM	Valve area may ave potential PCB impacts due to interconnections with other natural gas transmission systems. Transco did not use PCB lubricating oils in it's transmission systems. Petroleum based lubricants for maintenance at the facility.	None	NS	Yes	NS	Yes	NS	Aluminium, antimony, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, mercury, nickel, potassium, sodium, vanadium and zinc	NS
B & L Oil Corporation	1215 to 1219 Rt 508	BOMM	Transformer removal. Leaky valve asociated with former AST; diesel spill;	VOCs, SVOCs including PAHs, PCBs, TPHC	Benzene	Yes	NR	Yes	Yes	Antimony, beryllium, cadmium, mercury, vanadium and zinc	Aluminium, iron, potassium, zinc, magnesium, manganese, nickel, sodium and vanadium
Municipal Sanitary Landfill Authority	1500 Harrison Ave	BIDC	Fill including demolition waste (41%), industrial waste (29%), domestic waste (20%) and commercial waste (10%). Pool of waste oil may have been pumped onto the landfill during the construction of U.S. Route 280.	VOCs, PAHs and Pesticides	VOCs, SVOCs, Pesticides	No	Yes	Yes	Yes	None	Aluminium, barium, chromium, iron, manganese, nickel and sodium
Campbell Foundry Co	1235Harrison Ave	BFO-N	Storage of foundry stock. And wastes including baghouse dust, slag and casting sand. The baghouse dust was listed as D006 (leachable cadmium), D007 (leachable chromium), and D008 (leachable lead) hazardous waste.	PAHs	PAHs	No	Yes	Yes	Yes	Cadmium	Antimony, cadmium, copper, chromium, mercury, nickel and zinc
Keegan Landfill	437 Bergen Ave	OBR	Disposal of hazardous wastes was not prohibited from 1940 to 1972 at municipal wastes.	VOCs, PCBs, PAHs, Pesticides	VOCs	No	No	Yes	No	Aluminium, barium, chromium, iron and mercury	Iron and zinc
Port-o-San Corp	450 Bergen Ave	BFO-N	Fill material at site and nearby surrounding areas is composed of typical foundry waste, including slag, refractory brick, casting sand and metal waste; Former property owner (John Hewitt Foundry) is the suspected source due to the nature of the fill material. Benzene due to former and current gasoline and diesel fuel USTs.	PAHs, PCBs	Benzene	No	NA	Yes	NA	Beryllium, copper, nickel, thallium and zinc	NA; no wells

Notes:
BFO - N - Bureau of Field Operations - Northern
BISR - Bureau of Industrial Site Remediation (formerly BEECRA)
SA - Site Assesment
BUST - Bureau of Underground Storage Tanks
BCM - Bureau of Case Management
BOMM - Bureau of Operation, Maintenance and Management
BIDC - Bureau of Investigation, Design & Construction
OBR - Office of Brownfields Resuse
NA - Not available
NR - Not reported
NS - Not sampled
DRO - diesel range organics
Metal results are for unfiltered samples.

Table 2-4. Ranges of Metals Concentrations in Soil and Groundwater at the Reviewed Sites
Diamond Head Oil Superfund Site, Kearny, NJ

Site Name	Soil Concentration Range Above Peat					Soil Concentration Range Below Peat					Groundwater Concentration Range Above Peat					Groundwater Concentration Range Below Peat				
	Arsenic (mg/Kg)	Lead (mg/Kg)	Iron (mg/Kg)	Manganese (mg/Kg)	Sodium (mg/Kg)	Arsenic (mg/Kg)	Lead (mg/Kg)	Iron (mg/Kg)	Manganese (mg/Kg)	Sodium (mg/Kg)	Arsenic (ug/L)	Lead (ug/L)	Iron (ug/L)	Manganese (ug/L)	Sodium (ug/L)	Arsenic (ug/L)	Lead (ug/L)	Iron (ug/L)	Manganese (ug/L)	Sodium (ug/L)
Standards/criteria	NJIGWSCC: 19	NJIGWSCC: 59	NJIGWSCC: None	NJIGWSCC: 42	NJIGWSCC: None-	NJIGWSCC: 19	NJIGWSCC: 59	NJIGWSCC: None	NJIGWSCC: 42	NJIGWSCC: None-	Fed MCL: 10	Fed MCL: 15	Fed MCL: None	Fed MCL: None	Fed MCL: None	Fed MCL: 10	Fed MCL: 15	Fed MCL: None	Fed MCL: None	Fed MCL: None
	NJNRDRS: 19	NJNRDRS: 800	NJNRDRS: None	NJNRDRS: 5900	NJNRDRS: None	NJNRDRS: 19	NJNRDRS: 800	NJNRDRS: None	NJNRDRS: 5900	NJNRDRS: None	NJ Class IIA: 3	NJ Class IIA: 5	NJ Class IIA: 300	NJ Class IIA: 50	NJ Class IIA: 50,000	NJ Class IIA: 3	NJ Class IIA: 5	NJ Class IIA: 300	NJ Class IIA: 50	NJ Class IIA: 50,000
Diamond Head Oil Refinery Division	0.86J to 477J	2 to 37,200	2,890 to 20,1000J	33.8 to 2,470J	38.7J to 13,500J	1.2 to 20.2	2.6 to 310	8,090J to 34,200J	52.6 to 732J	161J to 1,030J	2J to 161	0.69J to 353	122 to 32,300	2.5 to 4,520	11,200 to 614,000	2.3J to 63.3	1.2 to 5	1,270 to 16,800	121J to 1,270J	263,000 to 656,000
A.L. Wilson Chemical Co	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SOS Gases Inc	Information was not available due to NJDEP filing system; files provided by NJDEP was comprised of reports on Weldon Asphalt Company which is located at 1100 Harrison Avenue, Kearny, New Jersey.										Information was not available due to NJDEP filing system; files provided by NJDEP was comprised of reports on Weldon Asphalt Company which is located at 1100 Harrison Avenue, Kearny, New Jersey.									
United States Postal Service Processing Center	15.1 to 5.91	320 to 791	NR	NR	NR	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	7.99 to 20	7.1 to 353	NR	NR	NR	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
Bergen Metal Company	NA	1.6 to 18.6	NR	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Central Salvage Co	1.25 to 5.74	42.2 to 3,230	NR	NR	NR	NA	NA	NA	NA	NA	4.14 to 860	2.96 to 17,800	NA	NA	NA	NS	NS	NA	NA	NA
Drew Chemical Corp	2.1 to 55.6	60.3B to 4,770B	NR	NR	NR	NS	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kearny Smelting & Refining Company	0.93 to 371	3 to 15,300	NR	NR	NR	1.1 to 2.1	2.5 to 26.6	8,090 to 34,200	52.6 to 732	161 to 1,030	3.6 to 836	2.1 to 1,810	NR	NR	NR	0.9 to 116	2.6 to 4.6	NR	NR	NR
Transcontinental Gas Pipeline Valve Passaic R	2.4 to 2.9	60.1 to 93.3	12,300 to 14,500	128 to 142	191 to 226	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B & L Oil Corporation	1.16 to 8,400	5.27 to 3,690	3,040 to 24,600	18 to 422	282 to 11,200	NS	NS	NS	NS	NS	5.28 to 17.8	2.6 to 24,600	22.9 to 17,000	433 to 62,300	8,980 to 147,000	NS	NS	NS	NS	NS
Municipal Sanitary Landfill Authority	1.3 to 18	2.9 J to 4,830	7,890 to 122,000	41.9 to 3,710	41.3J to 4,920	NS	NS	NS	NS	NS	5.2 to 41.8	6.4 to 2,620	389 to 224,000	24.2 to 221,000 E	200,000 to 3,970,000	5.8 to 45.4	5.9 to 250	462 to 108,000	49.7 to 3,420	122,000 to 8,660,000
Campbell Foundry Co	2.6 to 5.8	1.3 to 2,800	NR	NR	NR	NS	NS	NS	NS	NS	1.4 to 82	3.8 to 7,100	NR	NR	NR	NS	NS	NS	NS	NS
Keegan Landfill	NR	452 to 13,000	5,500 to 202,000	NR	NR	NS	258 to 23,000	NR	520	NR	NR	24 to 110				NS	NS			
Port-o-San Corp	6.32 to 10.8	1,650 to 9,080	NR	NR	NR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Notes:
NA - Not available
NR - Not reported
NS - Not sampled
[1] - Borings not advanced below the meadow-mat (organic/peat) layer.
[2] - The reported value was determined by the Method of Standard Additions (MSA)
B - estimated value
E - estimated value
J - estimated value
Stratified drift of glacial till overlies the Brunswick Formation.
The Brunswick aquifer is composed of sandstone, siltstone and shale of the Brunswick Formation.
Metal results are for unfiltered samples.

Table 2-5. Ranges of Metal Concentrations Ocurring in Soil in Urban Settings

Metal	Urban Background Concentrations of Metals in NJ Soils (1993 Study)[1]		Urban Piedmont Background Concentrations of Metals in NJ Soils (2003 Study)[2]	
	Arithmetic Mean (mg/kg)	Maximum (mg/kg)	Median (mg/kg)	90th Percentile (mg/kg)
Aluminum	NA	NA	10500	14400
Antimony	0.07	0.69	<DL	3.48
Arsenic	8.26	48.9	5.2	24.2
Barium	NA	NA	80.6	168
Beryllium	1.07	4.09	0.51	0.82
Cadmium	0.65	2.36	<DL	0.67
Calcium	NA	NA	1425	3010
Chromium	12.1	24.6	18.5	29.9
Cobalt	NA	NA	6.3	10.4
Copper	42.2	143	29.5	75.5
Iron	NA	NA	14600	20000
Lead	177.7	617	111	297
Magnesium	NA	NA	2190	4614
Manganese	335	952	311	859
Mercury	0.5	2.71	0.18	0.63
Nickel	16.6	53.8	12.4	24.6
Potassium	NA	NA	693	1524
Selenium	0.06	0.15	0.41	0.71
Silver	0.24	1.53	<DL	0.86
Sodium	NA	NA	90.1	141
Thallium	0.1	0.46	<DL	0.25
Vanadium	22.6	46.1	29.6	41.7
Zinc	162.3	789	75.3	162

Notes:

[1] - A Summary of Selected Soil Constituents and Contaminants at Background Locations in New Jersey (NJDEP, September 1993)

[2]- Ambient Levels of Metals in New Jersey Soils, NJDEP Division of Science Research and Technology (Sanders, May 2003)

DL - detection limit

NA - not available

Table 2-6. Ranges of Metal Concentrations in Surficial Groundwater at the Diamond Head Site and in the Underlying Stratified Drift and Brunswick Aquifers.
Diamond Head Oil Superfund Site, Kearny, NJ

Metal	(A) Federal MCL (ug/L)	(B) NJ Class IIA Std (ug/L)	Surficial Aquifer Groundwater Concentration Above Peat				Surficial Aquifer Groundwater Concentration Below Peat				Stratified Drift Aquifer		Brunswick Aquifer	
			Minimum Concentration (ug/L)	Validators Flag	Maximum Concentration (ug/L)	Validators Flag	Minimum Concentration (ug/L)	Validators Flag	Maximum Concentration (ug/L)	Validators Flag	Minimum Concentration (ug/L)	Maximum Concentration (ug/L)	Minimum Concentration (ug/L)	Maximum Concentration (ug/L)
Aluminum		200	6.9	J	4,540 [B]		76.5	J	380 [B]		3.2	21.6	1.1	5
Antimony	6	6	0.56	J	11.5 [AB]	J	0.64	J	1	J	0.10	1.29	0.07	0.15
Arsenic	10	3	2	J	161 [AB]		2.3	J	63.3 [AB]	J	1.26	6.3 [B]	0.2	7 [B]
Barium	2,000	6,000	6.8	J	935		30.3	J	381		28	351	77	380
Beryllium	4	1	no detects		no detects		0.11	J	0.34	J	0.02	0.16	0.005	0.25
Cadmium	5	4	0.11	J	2.9		no detects		no detects		0.02	1.15	0.04	0.5
Calcium			26,900		345,000		43,700		95,700		35.2	342	62	620
Chromium	100	70	3.3	J	3,590 [AB]	J	13.2		27.6	J	0.25	1.4	0.06	2.5
Cobalt			0.28	J	11.7	J	1.7	J	6.2		NR	NR	1.5	1.5
Copper	1,300	1,300	3.5	J	359		3.8	J	62.8	J	0.6	2.3	0.5	5
Iron		300	122		32,300 [B]		1,270 [B]		16,800 [B]		3	10,200 [B]	0	3,700 [B]
Lead	15	5	0.69	J	353 [AB]		1.2		5 [B]		0.04	0.06	0.04	20 [AB]
Magnesium			9,140		113,000		68,100		134,000		14.9	46.5	6.4	185
Manganese		50	2.5		4,520 [B]		121 [B]	J	1,270 [B]	J	1340 (B)	4900 (B)	0.5	750 (B)
Mercury	2	2	0.04	J	0.53		no detects		no detects		0.005	0.01	0.005	0.05
Nickel		100	7.3	J	171 [B]		3.9	J	14.9	J	0.93	24.5	0.99	5
Potassium			1,660	J	111,000		35,700		52,900		1.3	11.5	11	156
Selenium	50	40	3.5	J	490 [AB]		23	J	240 [B]	J	0.12	2.51	2.8	3.1
Silver			0.11	J	0.11	J	no detects		no detects		0.05	0.1	0.05	2
Sodium		50,000	11,200		614,000 [B]	J	263,000 [B]		656,000 [B]		52.6	142	1.1	7.5
Thallium	2	2	0.66	J	16.7 [AB]		no detects		no detects		0.02	0.02	0.02	0.02
Vanadium			0.32	J	669		24.8	J	1,950	J	NR	NR	3	23
Zinc		2,000	0.78	J	356		16.9	J	22.3	J	1.2	43.5	0.9	290

Notes:
J - estimated value
NR - Not reported
[A] - Federal maximum contaminant levels (MCLs) (posted at http://www.epa.gov/safewater/contaminants/index.html as of June 15, 2009) (USEPA 2009)
[B] - New Jersey groundwater quality standards (NJAC 7:9C Appendix 1 Specific Ground Water Quality Criteria)

Source: Hagstrom Union/Hudson/Essex County Atlas, 1990

Hudson County, Page 5, Grid C-7

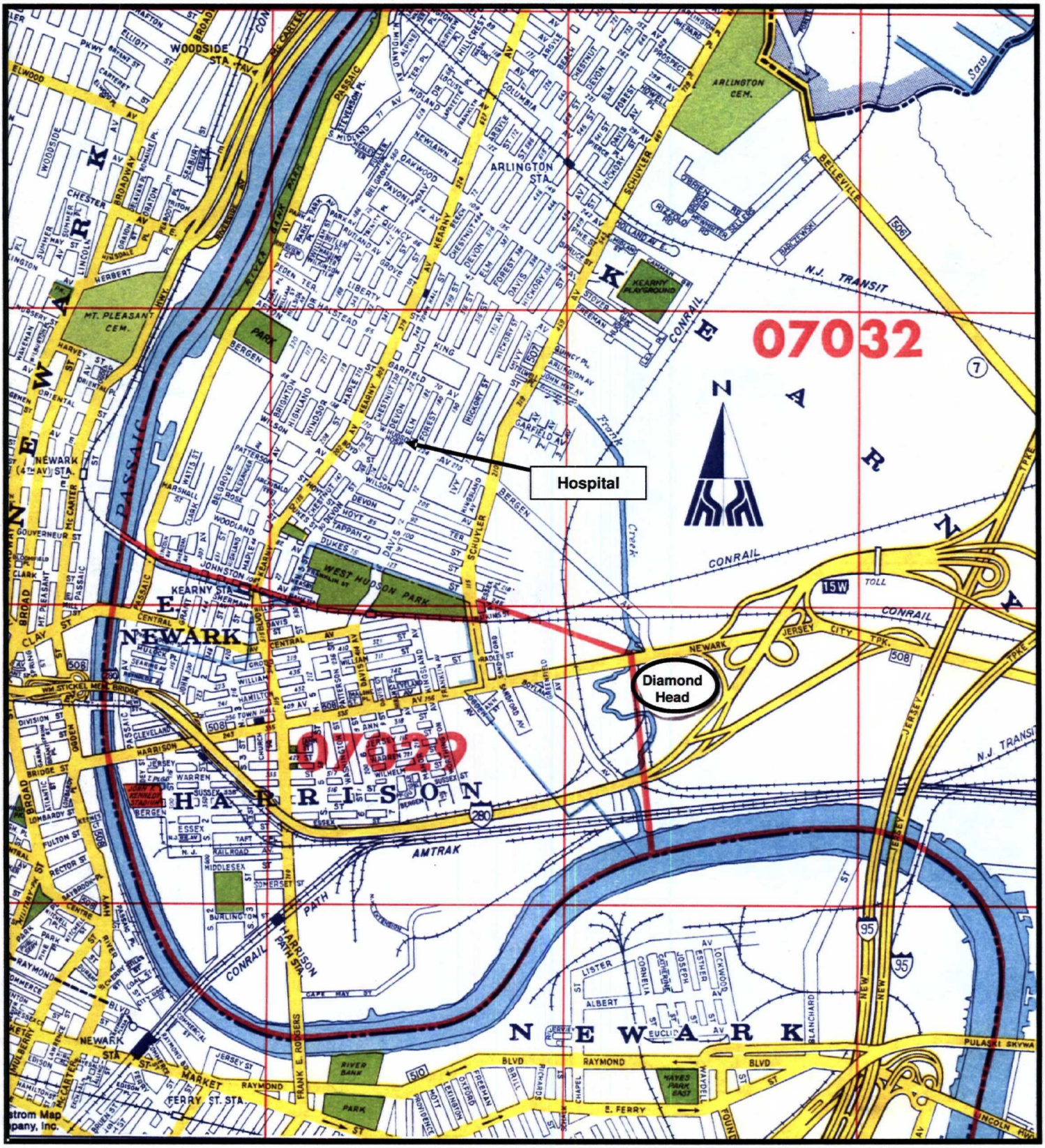


Figure 1-1

Diamond Head Oil - Site Location Map
Vacant Lot: *East of Campbell Foundry - 1235 Harrison Ave.*
Kearny, NJ 07032 (Hudson County)

See Also: USGS 7.5' Quadrangle: Elizabeth, NJ: Photorevised 1981
40° 44' 50" lat., 74° 07' 55.9" long. (NAD 83)

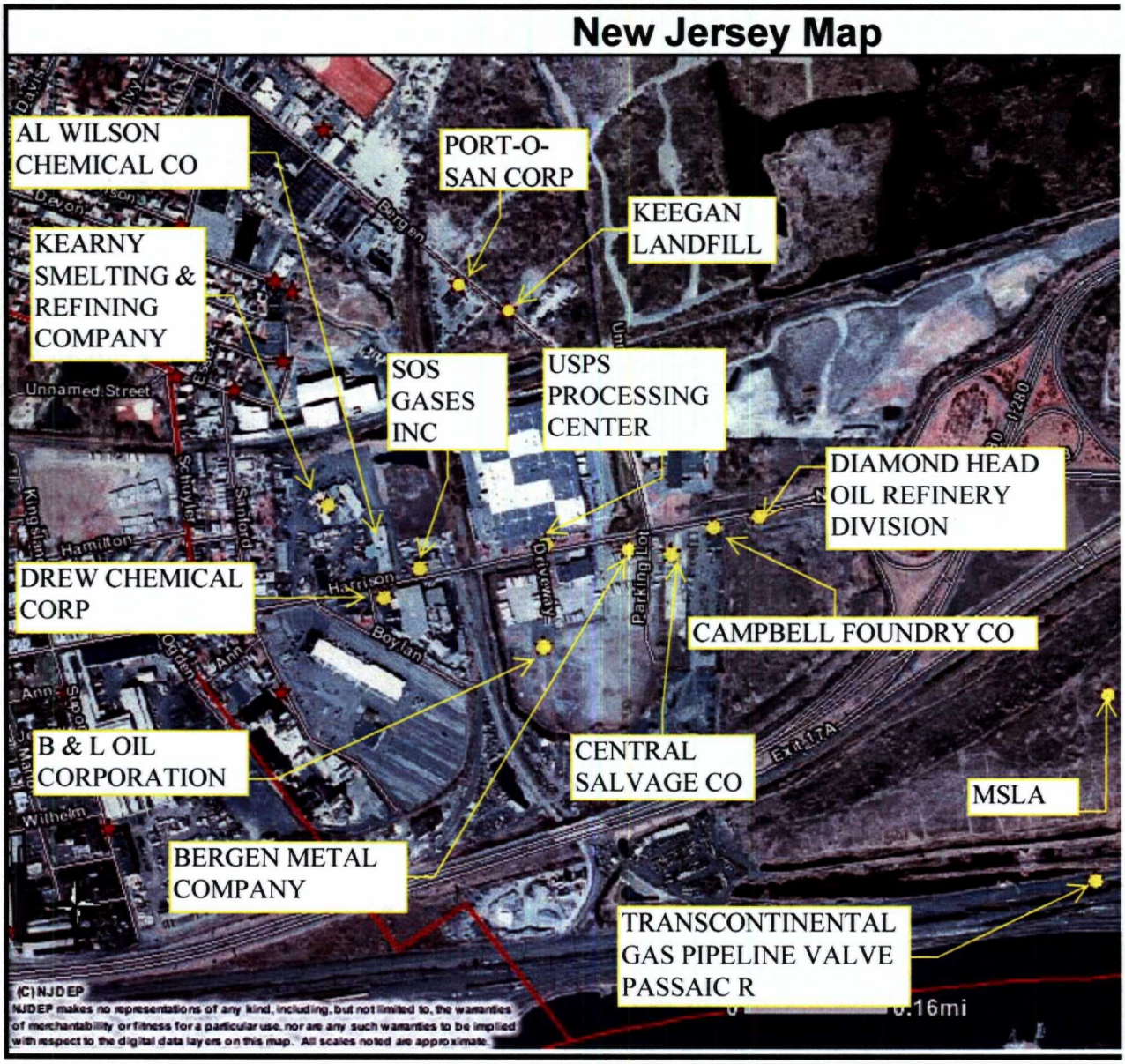
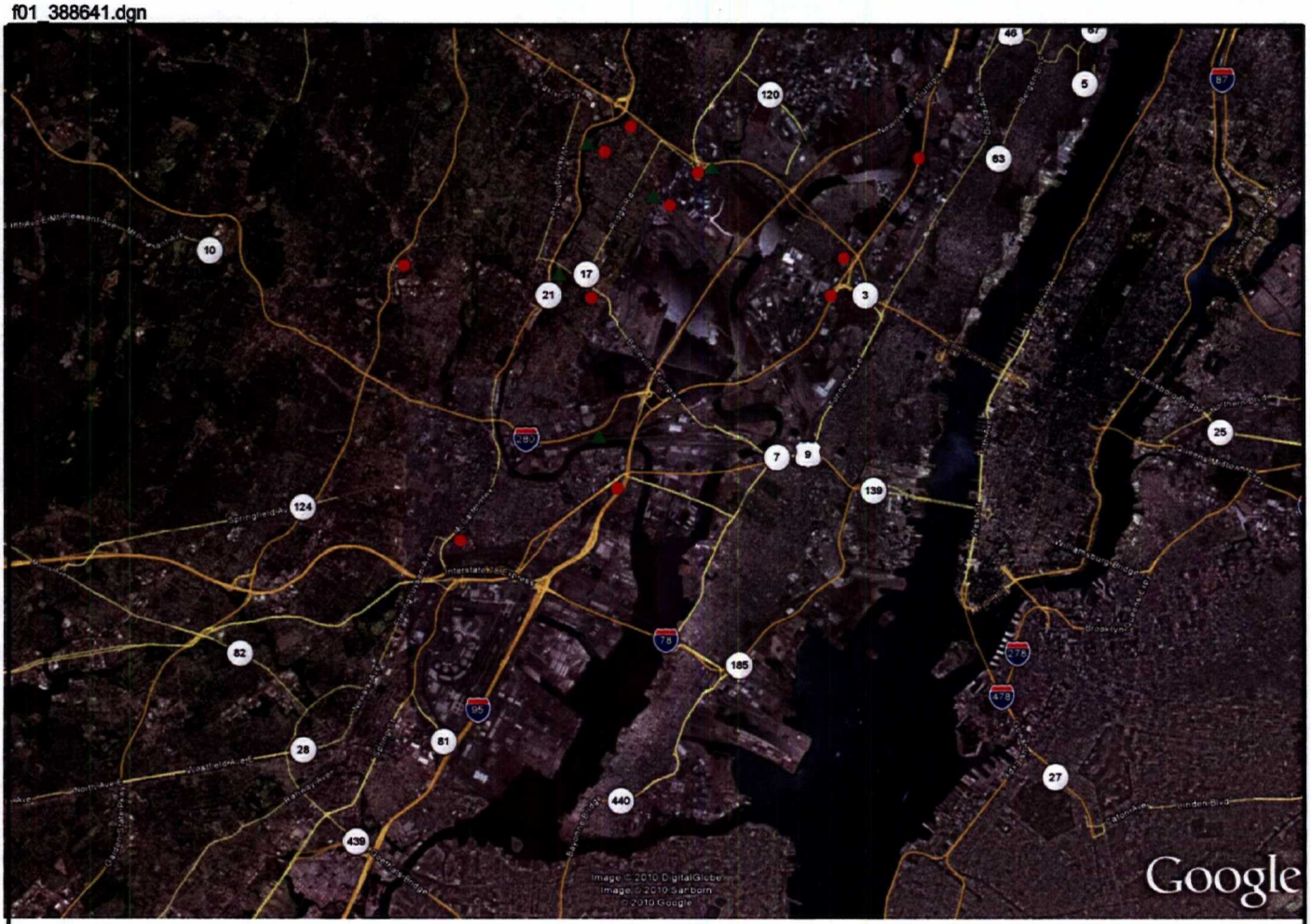
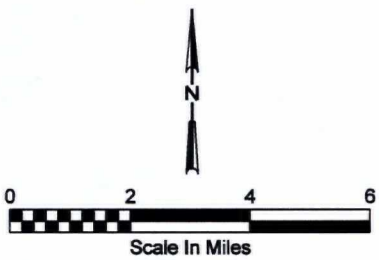


Figure 1-2. Known Contaminated Sites within 1/2 mile radius of Diamond Head Oil Superfund Site, Kearny, NJ

f01_388641.dgn





Legend

- ▲ Stratified Drift Aquifer
- ● Brunswick Aquifer
- ■ DHS Site

Figure 1-3
Location Map of USGS Well Samples around DHS Site
US Army Corps of Engineers
Diamond Head OU2

CH2MHILL

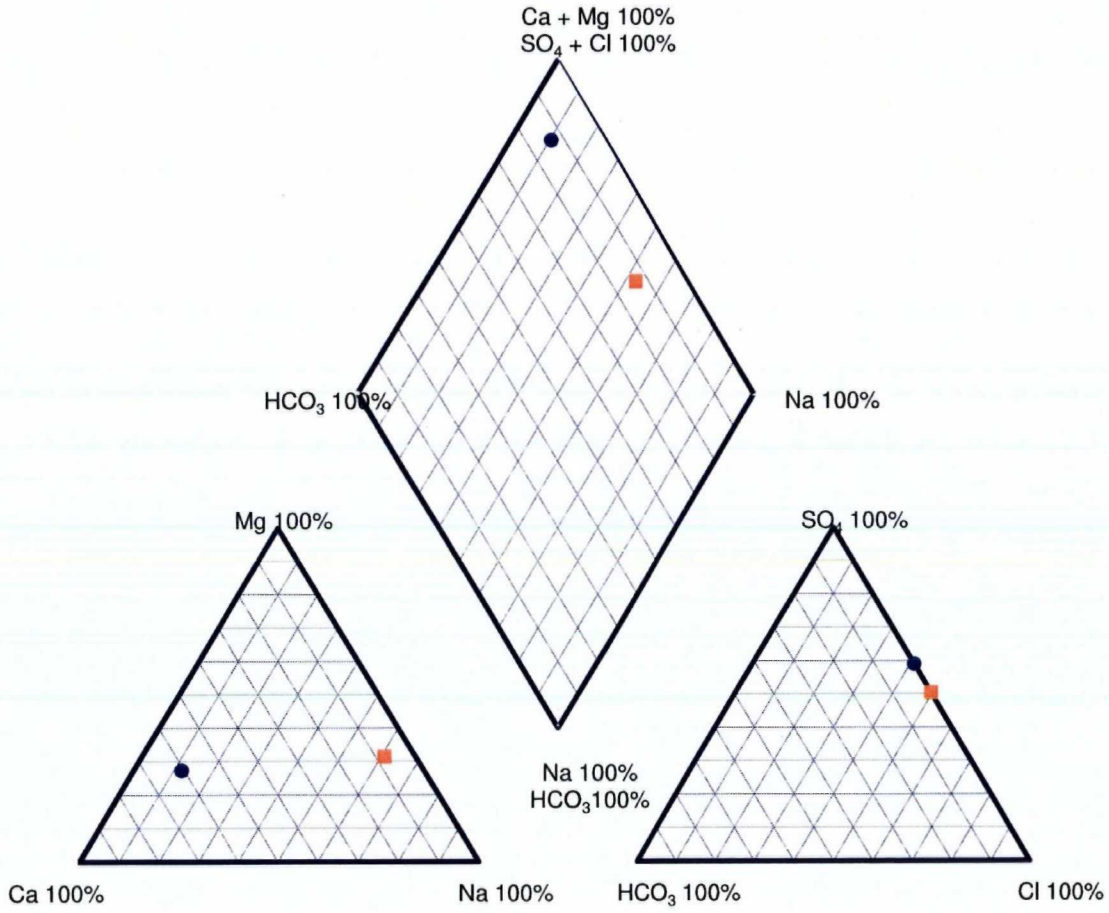


Figure 2-1A. Piper Plot for Surficial Water Bearing Unit at the DHS

LEGEND

- MW-11S-1: Aug 2003
- MW-11D-1: Aug 2003

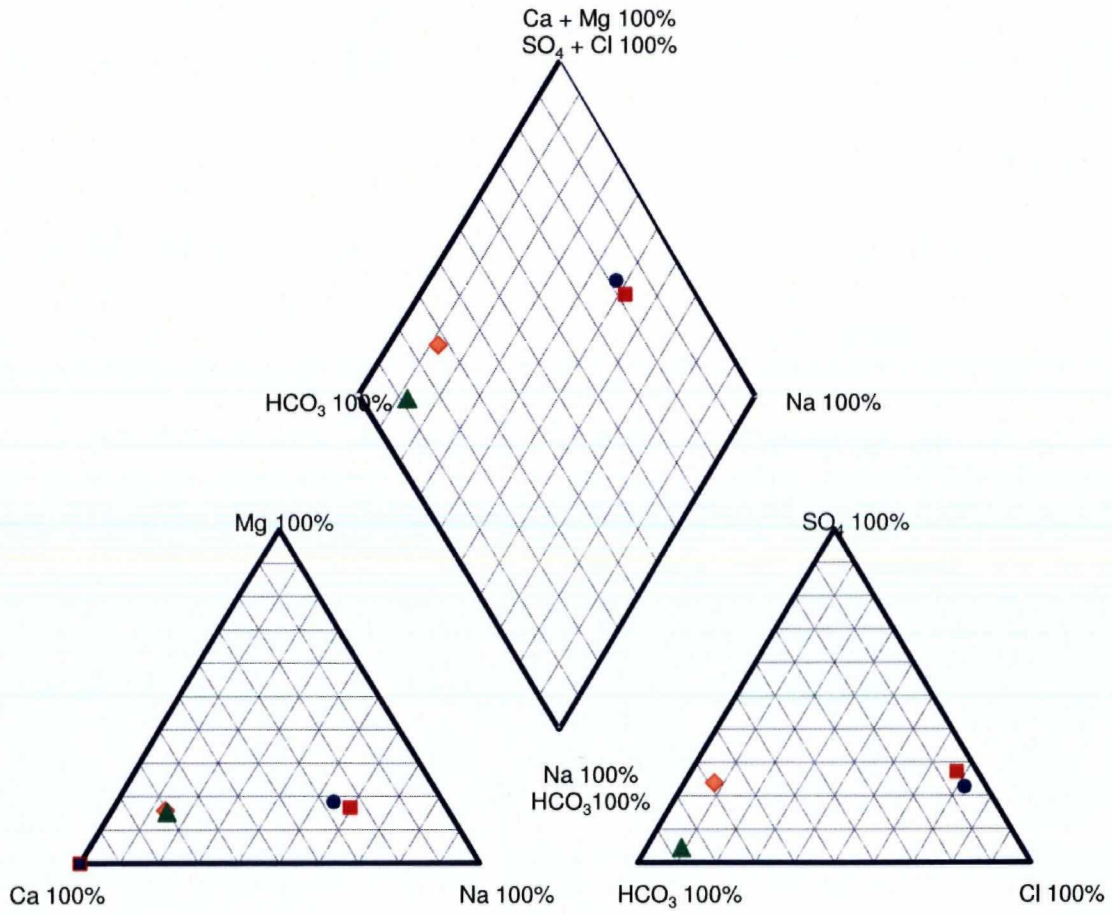


Figure 2-1B. Piper Plot for Stratified Drift Aquifer

LEGEND

- 404339074045401: May 2004
- 404339074045401: Apr 2008
- 404636074024701: Jun 2004
- 404636074024701: Aug 2008

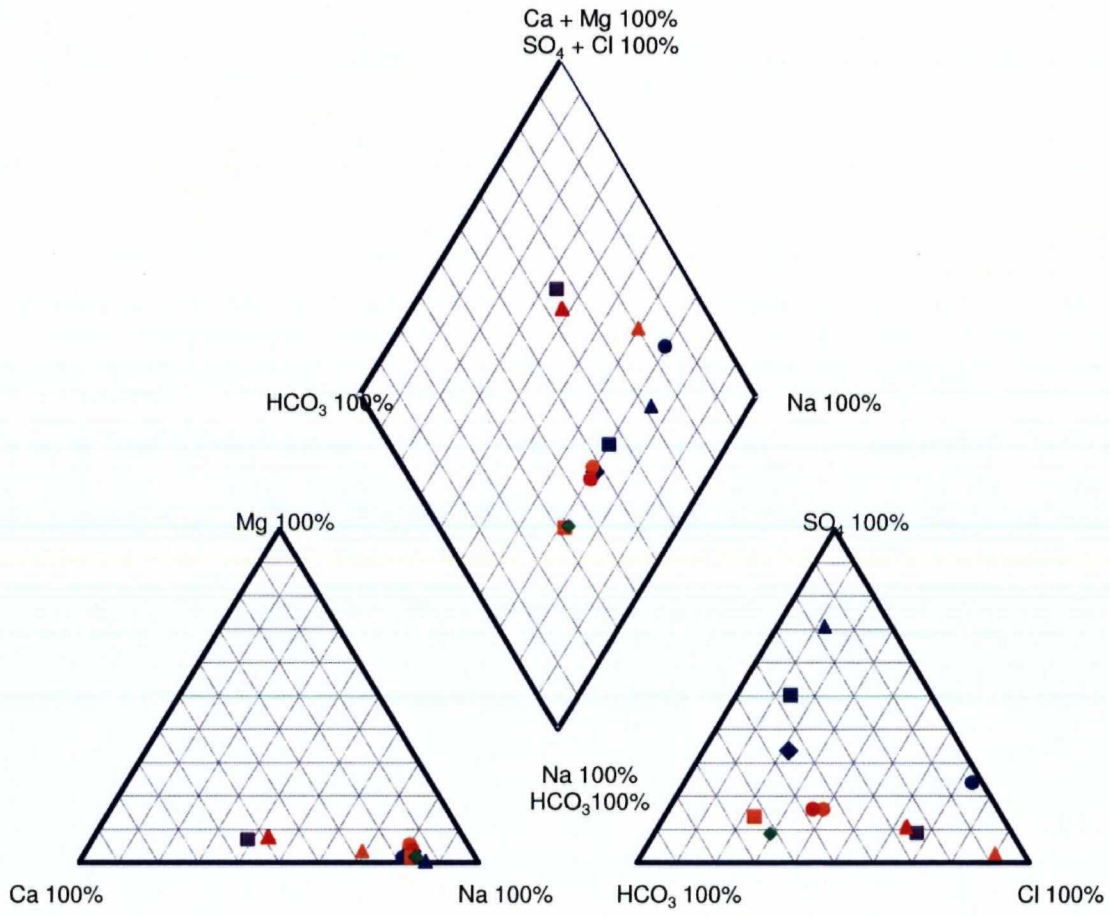


Figure 2-1C. Piper Plot for Brunswick Aquifer

LEGEND

- 404353074080001: May 1968
- 404713074033601: Apr 1969
- 404717074033501: Apr 1969
- 404819074063901: Sep 1988
- 404822074072201: Aug 1989
- 404829074072201: Aug 1989
- 404840074022901: Aug 1989
- 404844074065101: Aug 1989
- 404844074065101: Sep 2001
- 404332074104201: Sep 2003
- 404332074104201: Apr 2008

Figure 2-2. Iron Phase Diagram for Surficial Water Bearing Unit at DHS

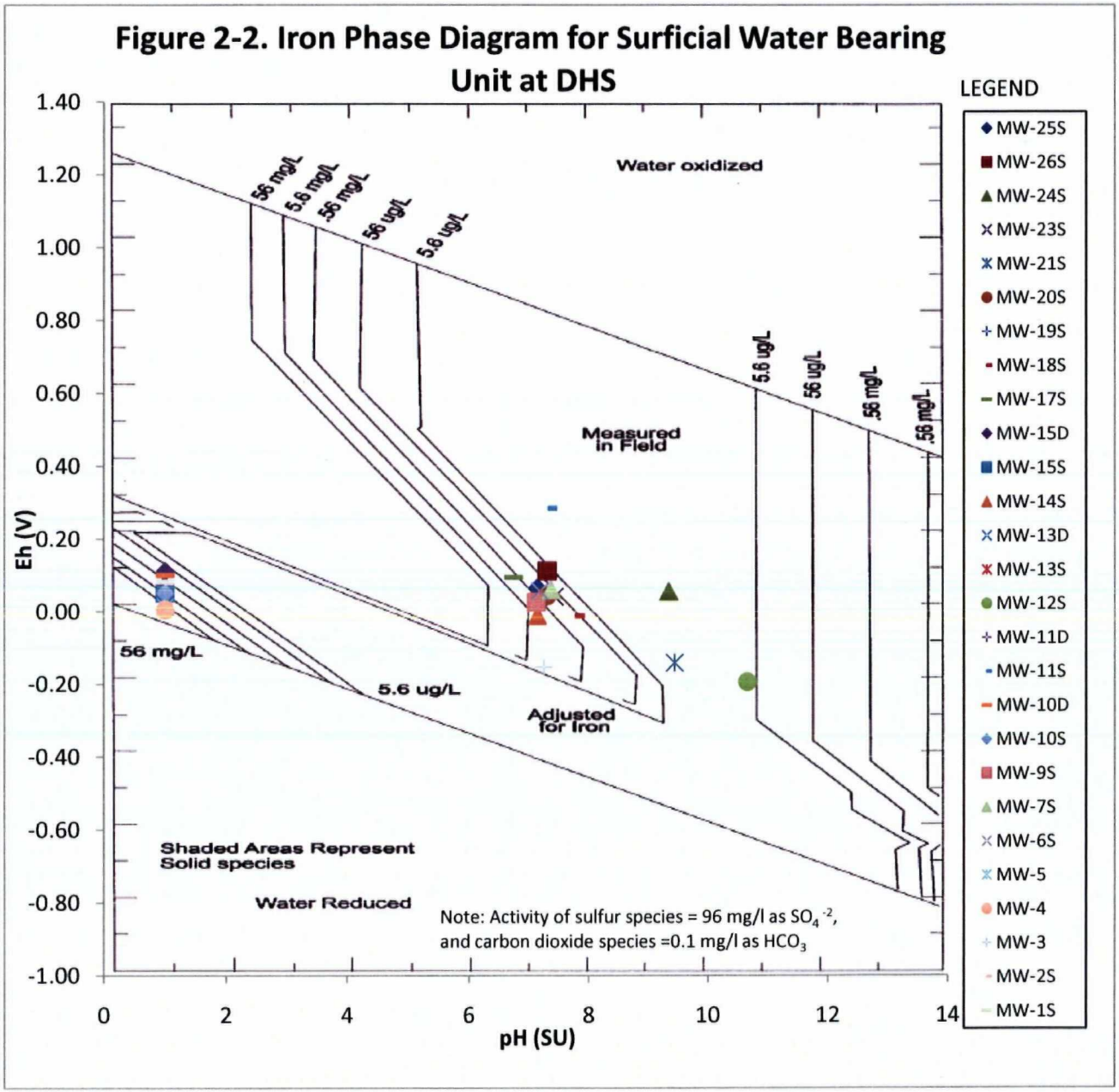


Figure 2-3. Iron Phase Diagram for Brunswick Aquifer

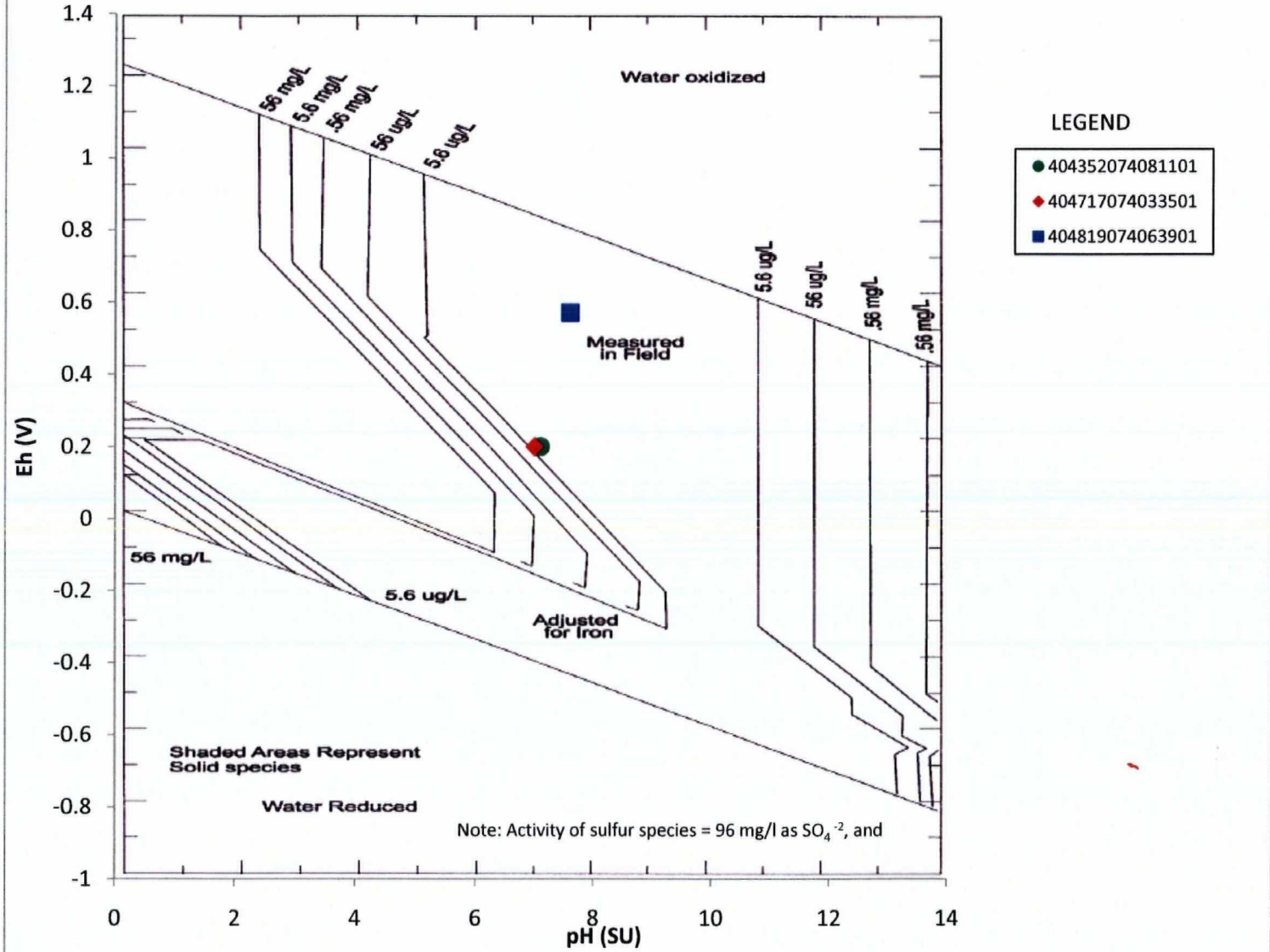


Figure 2-4. Manganese Phase Diagram for Surfical Water Bearing Unit at DHS

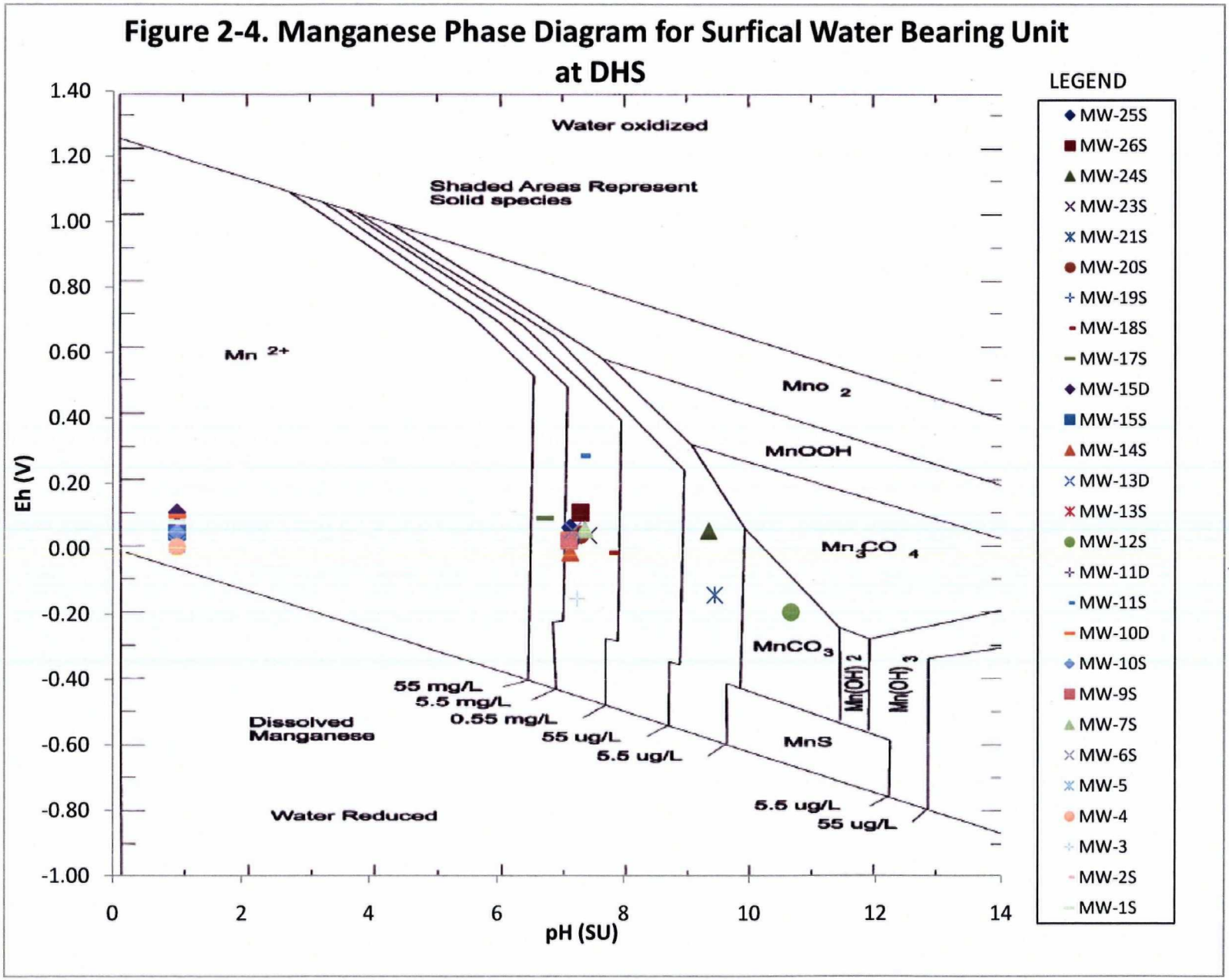


Figure 2-5. Manganese Phase Diagram for Brunswick Aquifer

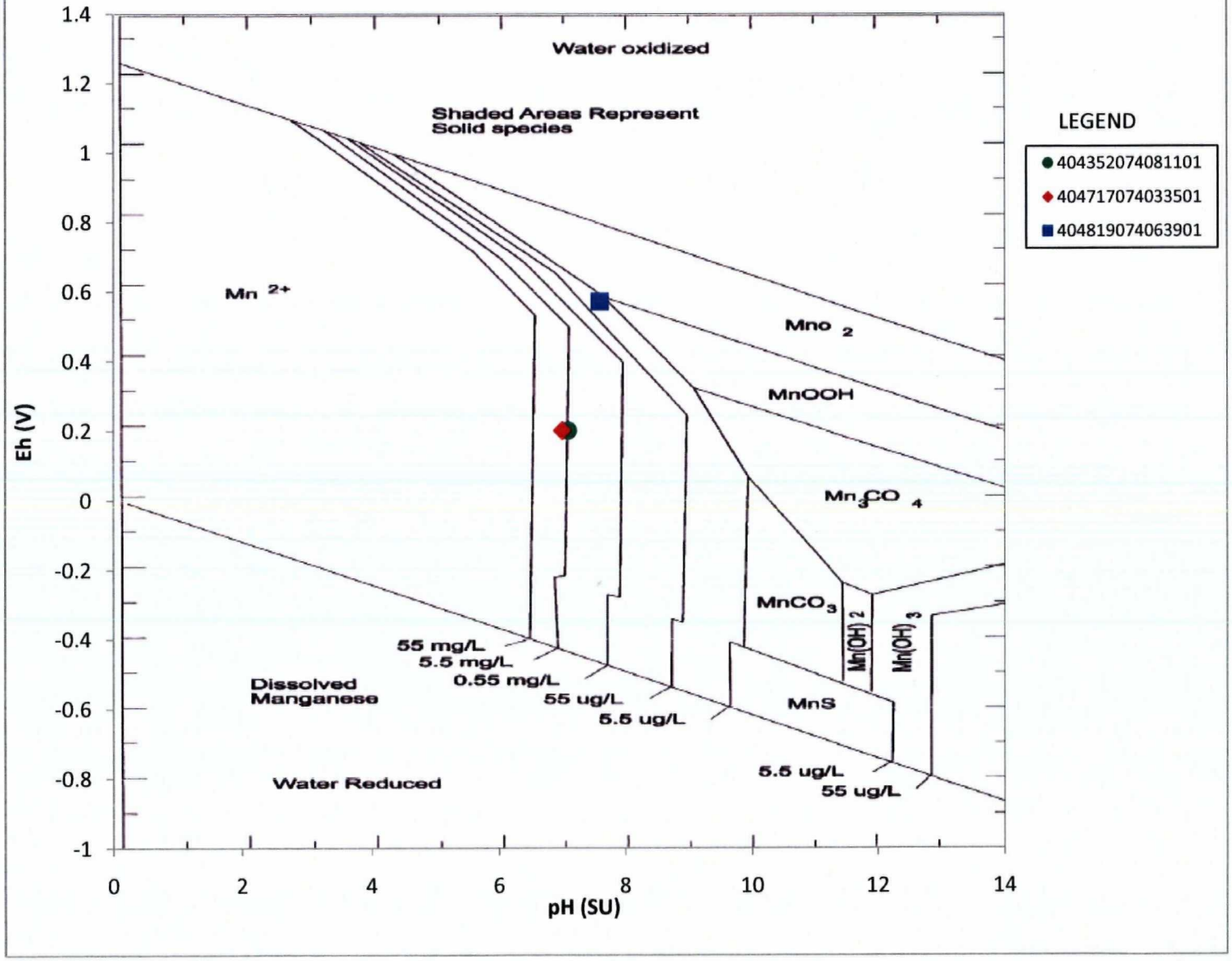


Figure 2-6. Arsenic Phase Diagram for Surficial Water Bearing Unit at DHS

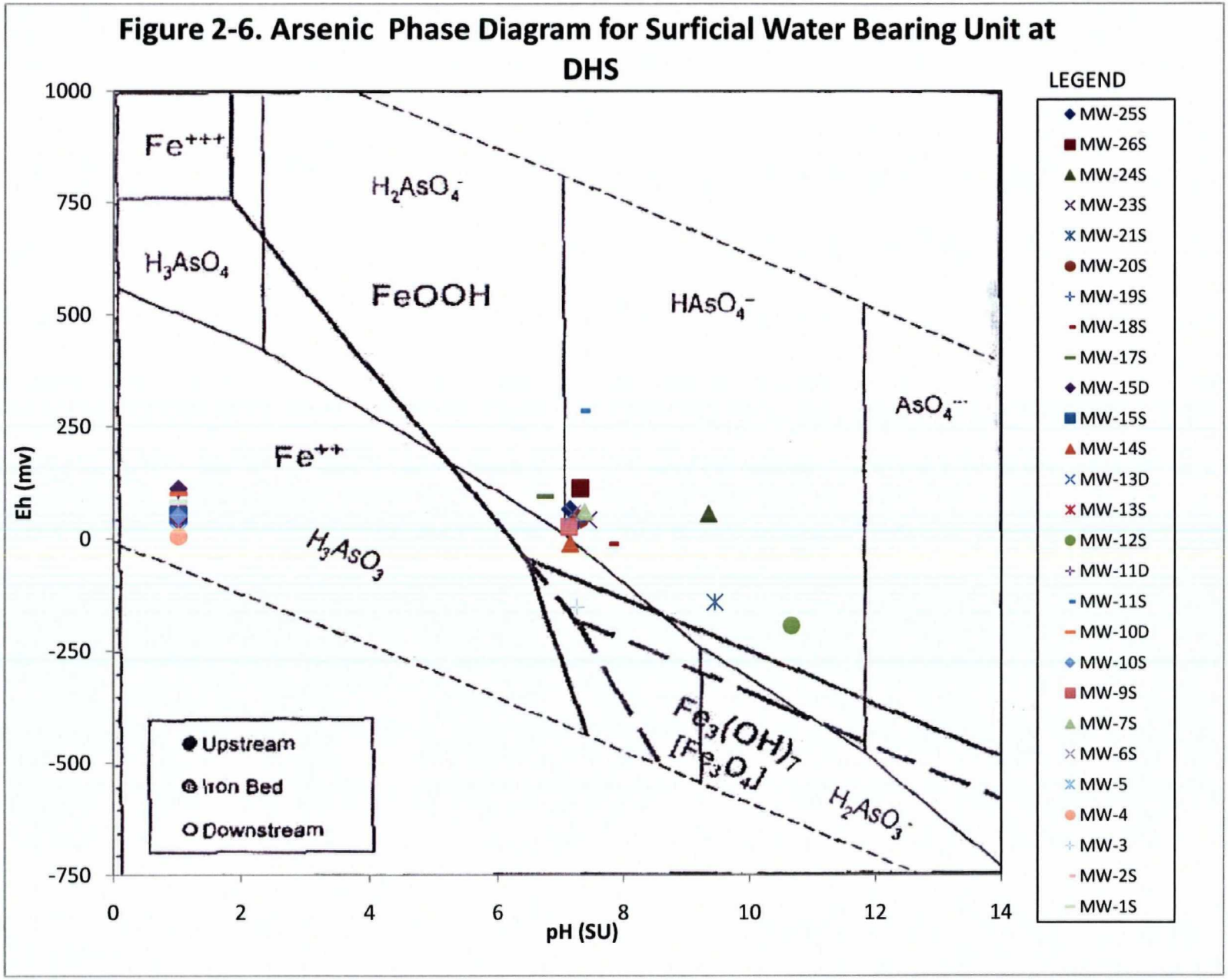


Figure 2-7. Arsenic Phase Diagram for Brunswick Aquifer

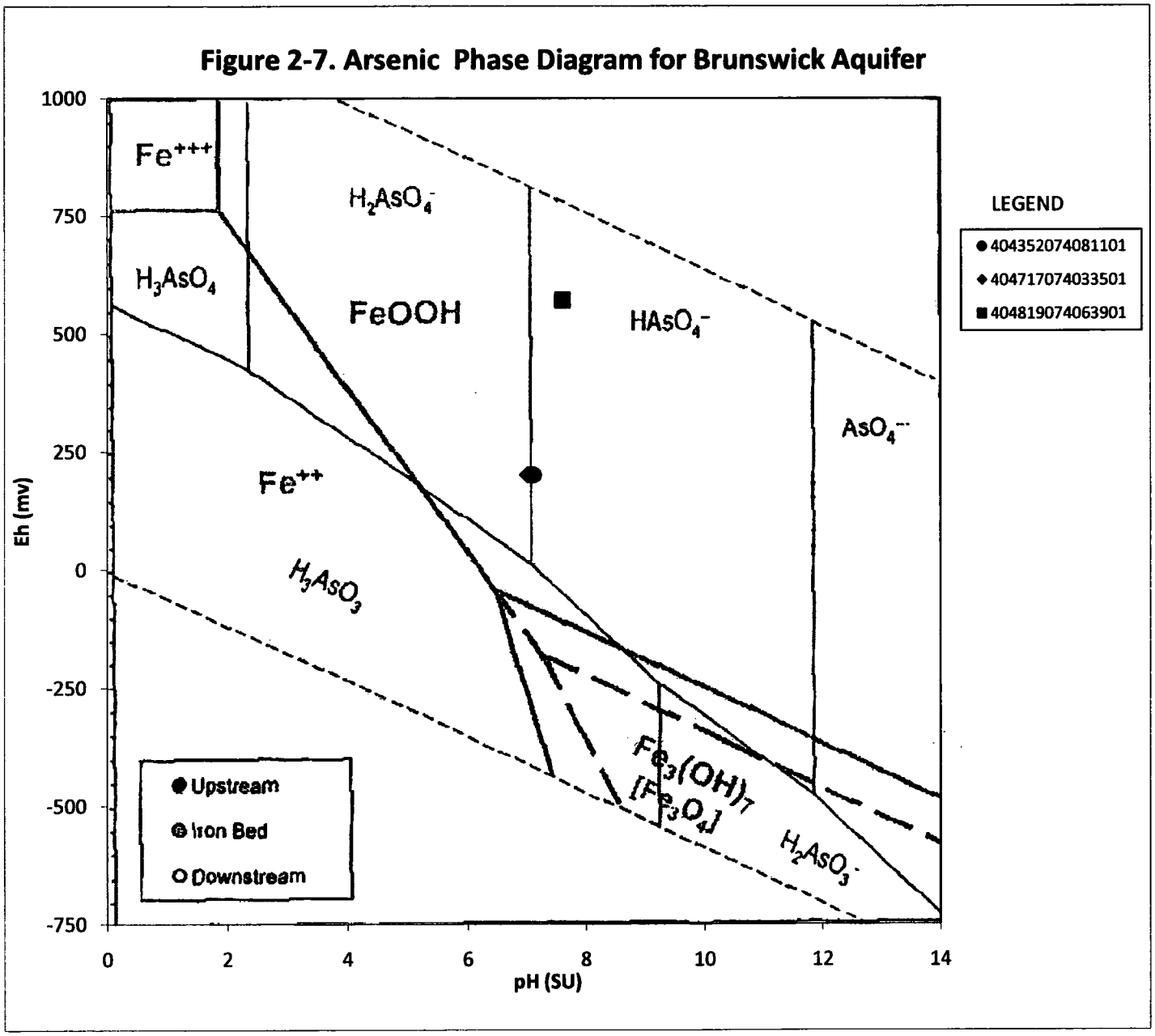


Figure 2-8. Lead Phase Diagram -for Surficial Water Bearing Unit at DHS

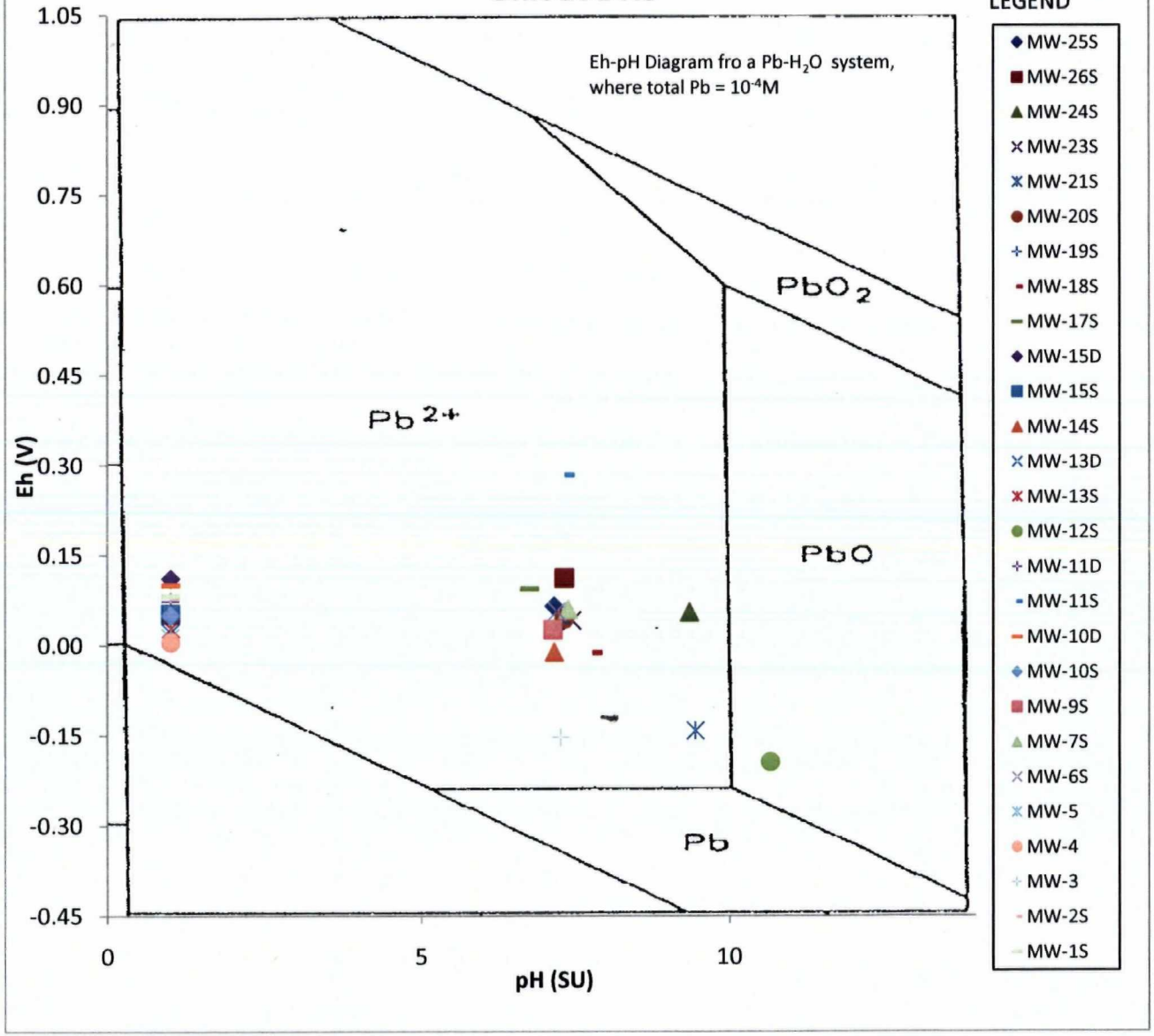
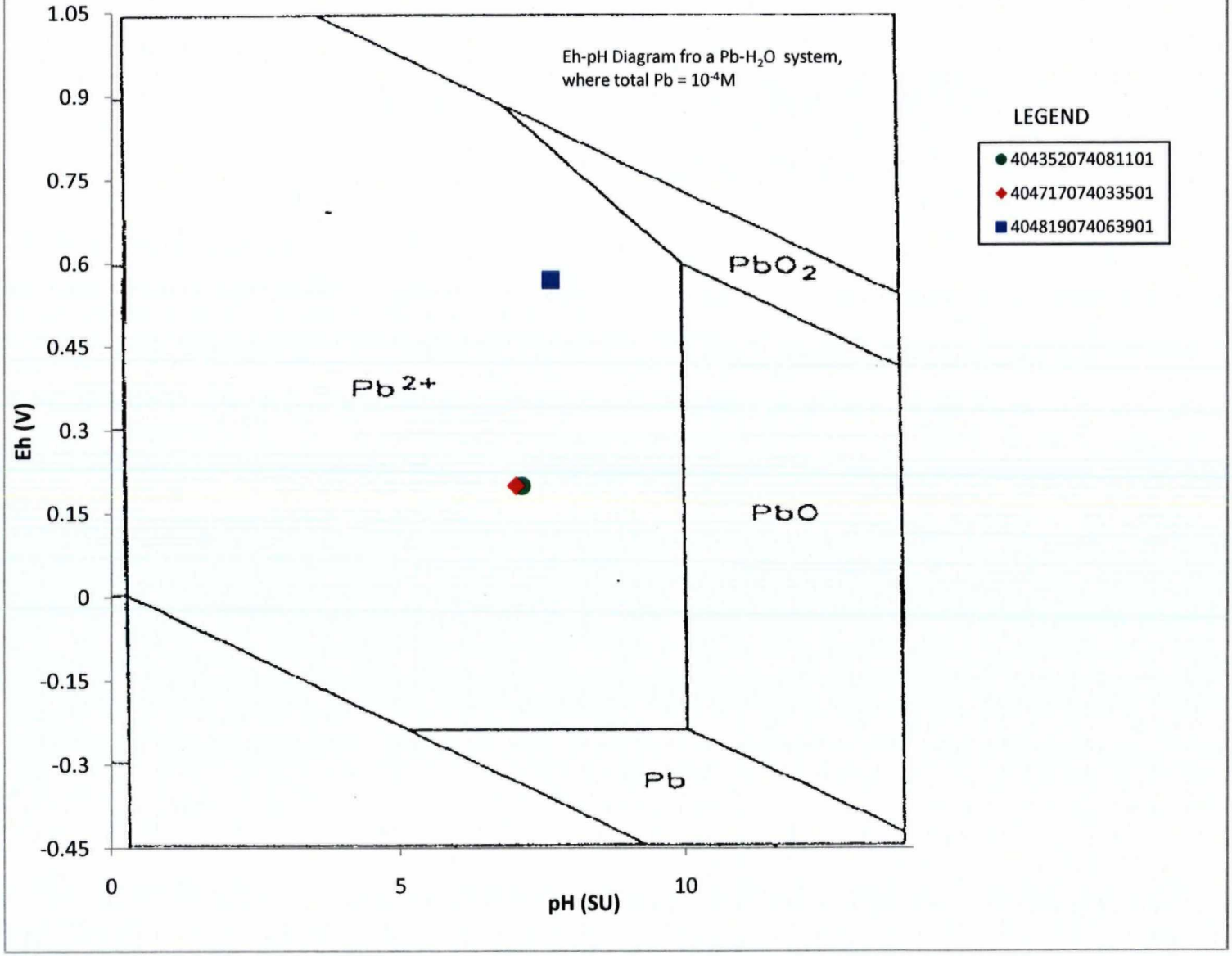


Figure 2-9. Lead Phase Diagram for Brunswick Aquifer



Appendices

Appendix A
Comparison of 2003 Concentrations of Metals in Subsurface Soil at DHS to Background Concentrations of Metals in NJ Soils

Appendix A
Comparison of 2003 Concentrations of Metals in Subsurface Soil at DHS to Background Concentrations of Metals in NJ Soils
Diamond Head Oil Superfund Site
Kearny NJ

	A	B	C	D	E	F	G	J	L	N	O
3	Phase 1 RI Soil Data (2003)							Background Concentrations of Metals in NJ Soils (1993 Study) [1]		Background Concentrations of Metals in NJ Soils (2003Study) [2]	
4	Location	Analytical Group / Sampling Location	Metal	Depth below ground surface (ft)	Sample Number	Concentration mg/kg		Arithmetic Mean (mg/kg)	Maximum (mg/kg)	Median (mg/kg)	90th Percentile (mg/kg)
6	SB-27	METAL	Aluminum	3 - 4	SB-27-03-04-1	286000	J	NA	NA	10500	14400
7		METAL	Antimony	3 - 4	SB-27-03-04-1	51.2	J	0.07	0.69	<DL	3.48
8		METAL	Arsenic	3 - 4	SB-27-03-04-1	19.4	J	8.26	48.9	5.2	24.2
9		METAL	Manganese	3 - 4	SB-27-03-04-1	150	J	335	952	311	859
10		METAL	Nickel	3 - 4	SB-27-03-04-1	114	J	16.6	53.8	12.4	24.6
11	SB-31	METAL	Aluminum	4 - 5	SB-31-04-05-1	14600		NA	NA	10500	14400
12		METAL	Antimony	4 - 5	SB-31-04-05-1	61.2	J	0.07	0.69	<DL	3.48
13		METAL	Arsenic	4 - 5	SB-31-04-05-1	24.2		8.26	48.9	5.2	24.2
14		METAL	Lead	4 - 5	SB-31-04-05-1	120		177.7	617	111	297
15		METAL	Manganese	4 - 5	SB-31-04-05-1	279		335	952	311	859
16		METAL	Mercury	4 - 5	SB-31-04-05-1	0.37	J	0.5	2.71	0.18	0.63
17		METAL	Nickel	4 - 5	SB-31-04-05-1	135		16.6	53.8	12.4	24.6
18	SB-33	METAL	Aluminum	1 - 3	SB-33-01-03-1	10500		NA	NA	10500	14400
19		METAL	Antimony	1 - 3	SB-33-01-03-1	21.2	J	0.07	0.69	<DL	3.48
20		METAL	Lead	1 - 3	SB-33-01-03-1	1500		177.7	617	111	297
21		METAL	Manganese	1 - 3	SB-33-01-03-1	692		335	952	311	859
22		METAL	Nickel	1 - 3	SB-33-01-03-1	114		16.6	53.8	12.4	24.6
23	SB-34	METAL	Aluminum	1 - 3	SB-34-01-03-1	123000	J	NA	NA	10500	14400
24		METAL	Antimony	1 - 3	SB-34-01-03-1	20.2	J	0.07	0.69	<DL	3.48
25		METAL	Cadmium	1 - 3	SB-34-01-03-1	4.8	J	0.65	2.36	<DL	0.67
26		METAL	Cobalt	1 - 3	SB-34-01-03-1-D	259	J	NA	NA	6.3	10.4
27		METAL	Manganese	1 - 3	SB-34-01-03-1	898	J	335	952	311	859
28		METAL	Mercury	1 - 3	SB-34-01-03-1	0.16	J	0.5	2.71	0.18	0.63
29		METAL	Nickel	1 - 3	SB-34-01-03-1	1550	J	16.6	53.8	12.4	24.6
30		METAL	Silver	1 - 3	SB-34-01-03-1	10.6	J	0.24	1.53	<DL	0.86
31		METAL	Thallium	1 - 3	SB-34-01-03-1-D	13.9	J	0.1	0.46	<DL	0.25
32		METAL	Zinc	1 - 3	SB-34-01-03-1	1570	J	162.3	789	75.3	162
33	SB-36	METAL	Aluminum	2 - 4	SB-36-02-04-1	16300		NA	NA	10500	14400
34		METAL	Cadmium	2 - 4	SB-36-02-04-1	39.3		0.65	2.36	<DL	0.67
35		METAL	Lead	2 - 4	SB-36-02-04-1	1480		177.7	617	111	297
36		METAL	Manganese	2 - 4	SB-36-02-04-1	641		335	952	311	859
37		METAL	Mercury	2 - 4	SB-36-02-04-1	0.69	J	0.5	2.71	0.18	0.63
38		METAL	Nickel	2 - 4	SB-36-02-04-1	87.2		16.6	53.8	12.4	24.6
39		METAL	Silver	2 - 4	SB-36-02-04-1	1.9	J	0.24	1.53	<DL	0.86
40		METAL	Thallium	2 - 4	SB-36-02-04-1	3.7	J	0.1	0.46	<DL	0.25
41		METAL	Zinc	2 - 4	SB-36-02-04-1	1710		162.3	789	75.3	162
42	SB-MW-06S	METAL	Aluminum	4 - 5	SB-MW-06S-04-05-1	9050		NA	NA	10500	14400
43		METAL	Lead	4 - 5	SB-MW-06S-04-05-1	225		177.7	617	111	297
44		METAL	Manganese	4 - 5	SB-MW-06S-04-05-1	104		335	952	311	859
45		METAL	Mercury	4 - 5	SB-MW-06S-04-05-1	2.3	J	0.5	2.71	0.18	0.63
46	SB-MW-07S	METAL	Aluminum	2 - 3	SB-MW-07S-02-03-1	31100		NA	NA	10500	14400
47		METAL	Cadmium	2 - 3	SB-MW-07S-02-03-1	5		0.65	2.36	<DL	0.67
48		METAL	Cobalt	2 - 3	SB-MW-07S-02-03-1	159		NA	NA	6.3	10.4
49		METAL	Lead	2 - 3	SB-MW-07S-02-03-1	316		177.7	617	111	297
50		METAL	Manganese	2 - 3	SB-MW-07S-02-03-1	667		335	952	311	859
51		METAL	Mercury	2 - 3	SB-MW-07S-02-03-1	0.81	J	0.5	2.71	0.18	0.63
52		METAL	Nickel	2 - 3	SB-MW-07S-02-03-1	595		16.6	53.8	12.4	24.6
53		METAL	Thallium	2 - 3	SB-MW-07S-02-03-1	9.2		0.1	0.46	<DL	0.25
54	SB-MW-10D	METAL	Aluminum	4 - 5	SB-MW-10D-04-05-1	11900		NA	NA	10500	14400
55		METAL	Antimony	4 - 5	SB-MW-10D-04-05-1	7.1	J	0.07	0.69	<DL	3.48
56		METAL	Cadmium	4 - 5	SB-MW-10D-04-05-1	1.4		0.65	2.36	<DL	0.67
57		METAL	Lead	4 - 5	SB-MW-10D-04-05-1	1100		177.7	617	111	297
58		METAL	Manganese	4 - 5	SB-MW-10D-04-05-1	891		335	952	311	859
59		METAL	Mercury	4 - 5	SB-MW-10D-04-05-1	0.23		0.5	2.71	0.18	0.63
60		METAL	Silver	4 - 5	SB-MW-10D-04-05-1	1.2	J	0.24	1.53	<DL	0.86
61		METAL	Thallium	4 - 5	SB-MW-10D-04-05-1	3.2	J	0.1	0.46	<DL	0.25
62	SB-MW-12S	METAL	Aluminum	2 - 3	SB-MW-12S-02-03-1	15600		NA	NA	10500	14400
63		METAL	Cadmium	2 - 3	SB-MW-12S-02-03-1	1.4	J	0.65	2.36	<DL	0.67
64		METAL	Lead	2 - 3	SB-MW-12S-02-03-1	1520		177.7	617	111	297
65		METAL	Manganese	2 - 3	SB-MW-12S-02-03-1	352		335	952	311	859
66		METAL	Mercury	2 - 3	SB-MW-12S-02-03-1	1.1	J	0.5	2.71	0.18	0.63
67	SB-MW-13D	METAL	Aluminum	2 - 3	SB-MW-13D-02-03-1	4130	J	NA	NA	10500	14400
68		METAL	Lead	2 - 3	SB-MW-13D-02-03-1	1150	J	177.7	617	111	297
69		METAL	Manganese	2 - 3	SB-MW-13D-02-03-1	109	J	335	952	311	859
70		METAL	Mercury	2 - 3	SB-MW-13D-02-03-1	0.28		0.5	2.71	0.18	0.63
71		METAL	Aluminum	5 - 6	SB-MW-13D-05-06-1	20000	J	NA	NA	10500	14400
72	SB-MW-14S	METAL	Aluminum	2 - 3	SB-MW-14S-02-03-1	5610	J	NA	NA	10500	14400
73		METAL	Manganese	2 - 3	SB-MW-14S-02-03-1	163		335	952	311	859
74	SB-MW-15D	METAL	Aluminum	4 - 6	SB-MW-15D-04-06-1	17900		NA	NA	10500	14400
75		METAL	Antimony	4 - 6	SB-MW-15D-04-06-1	8.4	J	0.07	0.69	<DL	3.48
76		METAL	Arsenic	4 - 6	SB-MW-15D-04-06-1	48		8.26	48.9	5.2	24.2
77		METAL	Cadmium	4 - 6	SB-MW-15D-04-06-1	14.2		0.65	2.36	<DL	0.67
78		METAL	Lead	4 - 6	SB-MW-15D-04-06-1	756		177.7	617	111	297
79		METAL	Manganese	4 - 6	SB-MW-15D-04-06-1	354		335	952	311	859
80		METAL	Mercury	4 - 6	SB-MW-15D-04-06-1	6.1		0.5	2.71	0.18	0.63
81		METAL	Nickel	4 - 6	SB-MW-15D-04-06-1	112		16.6	53.8	12.4	24.6
82		METAL	Silver	4 - 6	SB-MW-15D-04-06-1	5	J	0.24	1.53	<DL	0.86
83		METAL	Thallium	4 - 6	SB-MW-15D-04-06-1	3.3	J	0.1	0.46	<DL	0.25

Appendix A
Comparison of 2003 Concentrations of Metals in Subsurface Soil at DHS to Background Concentrations of Metals in NJ Soils
Diamond Head Oil Superfund Site
Kearny NJ

	A	B	C	D	E	F	G	J	L	N	O
84		METAL	Zinc	4 - 6	SB-MW-15D-04-06-1	3980		162.3	789	75.3	162
85	SB-PZ-14	METAL	Aluminum	2 - 3	SB-PZ-14-02-03-1	6720	J	NA	NA	10500	14400
86		METAL	Cadmium	2 - 3	SB-PZ-14-02-03-1	2	J	0.65	2.36	<DL	0.67
87		METAL	Lead	2 - 3	SB-PZ-14-02-03-1	1710	J	177.7	617	111	297
88		METAL	Manganese	2 - 3	SB-PZ-14-02-03-1	239	J	335	952	311	859
89		METAL	Mercury	2 - 3	SB-PZ-14-02-03-1	0.48	J	0.5	2.71	0.18	0.63
90	SB-PZ-16	METAL	Aluminum	4 - 5	SB-PZ-16-04-05-1	13900		NA	NA	10500	14400
91		METAL	Antimony	4 - 5	SB-PZ-16-04-05-1	39	J	0.07	0.69	<DL	3.48
92		METAL	Cadmium	4 - 5	SB-PZ-16-04-05-1	2.4		0.65	2.36	<DL	0.67
93		METAL	Cobalt	4 - 5	SB-PZ-16-04-05-1	78.6		NA	NA	6.3	10.4
94		METAL	Lead	4 - 5	SB-PZ-16-04-05-1	1370		177.7	617	111	297
95		METAL	Manganese	4 - 5	SB-PZ-16-04-05-1	502		335	952	311	859
96		METAL	Mercury	4 - 5	SB-PZ-16-04-05-1	0.42		0.5	2.71	0.18	0.63
97		METAL	Nickel	4 - 5	SB-PZ-16-04-05-1	261	J	16.6	53.8	12.4	24.6
98		METAL	Selenium	4 - 5	SB-PZ-16-04-05-1	8.3		0.06	0.15	0.41	0.71
99		METAL	Thallium	4 - 5	SB-PZ-16-04-05-1	3.7	J	0.1	0.46	<DL	0.25
100	SB-PZ-17	METAL	Aluminum	1 - 2	SB-PZ-17-01-02-1	10900		NA	NA	10500	14400
101		METAL	Antimony	1 - 2	SB-PZ-17-01-02-1	10	J	0.07	0.69	<DL	3.48
102		METAL	Arsenic	1 - 2	SB-PZ-17-01-02-1	35.1		8.26	48.9	5.2	24.2
103		METAL	Cadmium	1 - 2	SB-PZ-17-01-02-1	3.3		0.65	2.36	<DL	0.67
104		METAL	Lead	1 - 2	SB-PZ-17-01-02-1	804		177.7	617	111	297
105		METAL	Manganese	1 - 2	SB-PZ-17-01-02-1	143		335	952	311	859
106		METAL	Mercury	1 - 2	SB-PZ-17-01-02-1	6.9		0.5	2.71	0.18	0.63
107		METAL	Nickel	1 - 2	SB-PZ-17-01-02-1	50.2	J	16.6	53.8	12.4	24.6
108		METAL	Silver	1 - 2	SB-PZ-17-01-02-1	4.3	J	0.24	1.53	<DL	0.86
109											
110	**Notes:**										
111	1 - A Summary of Selected Soil Constituents and Contaminants at Background Locations in New Jersey - New Jersey Department of										
112	Environmental Protection & Energy Site Remediation Program and Division of Science and Research (September, 1993)										
113	2- Ambient Levels of Metals in New Jersey Soils, NJDEP Division of Sceience Research and Technology (May, 2003)										
114	<DL - Less than Detection Limit										
115	J - Estimated value										
116	Data evaluated includes 2003 soil samples collected up to a maximum depth of 5 feet below grade surface.										
117											
118	= 1993 Background Arithmic Mean Concentration Less than Onsite Concentration										
119	= 1993 Background Maximum Concentration Less than Onsite Concentration										
120	= 2003 Background Median Concentration Less than Onsite Concentration										
121											

Appendix B
General Water Quality Results of Groundwater Samples at DHS

Appendix B
General Water Quality Results of Groundwater Samples at DHS
Diamond Head Oil Superfund Site
Kearny, NJ

Sampling Location	MW-11S	MW-11D
Sample Depth	Above Peat	Below Peat
Sample ID	MW-11S-1	MW-11D-1
Lab Sample Number	R3983-01	R3983-02
Sampling Date	8/25/03	8/25/03
Matrix	WATER	WATER
Dilution Factor	1.0	1.0
Units	mg/L	mg/L
Alkalinity	570.00	1500.00
Ammonia	21	42
BOD	29	63
Carbon Dioxide	ND	66
Chloride	72	24
COD	170	330
Ferrous Iron	ND	ND
Hardness, total	109	659
NO3	ND	ND
NO2	ND	ND
Total Phosphorus	0.200	0.820
Sulfate	140.00	33
Sulfide	ND	ND
TDS	783	1700
TKN	20	53
TOC	70	130
TSS	34	17
Methane	26.5 D	3.91
Ethylene	ND	ND
Ethane	ND	ND

Notes:
D - Result from diluted analysis of sample.

Appendix C
Summary of Groundwater Quality Parameters based on June 2009 Groundwater Sampling Event

Appendix C. Summary of Groundwater Quality Parameters Based on June 2009 Groundwater Sampling Event
Diamond Head Oil Superfund Site, Kearny, NJ

Well ID	pH (SU)	Temperature (ºC)	Conductivity (mS/cm)	ORP (mV)	D.O. [Surface] (mg/L)	Turbidity/ LaMotte (NTU)
	+/- 0.1		+/- 3 %	+/- 10 mV	+/- 10 %	+/- 10%
MW-26S	7.31	16.68	2.81	-88	5	196/69.7
MW-25S	7.15	NM	2.35	-135	0.51	126/33.5
MW-24S	9.35	22.97	0.430	-145	0.7	62.9/0.14
MW-23S	7.44	19.22	1.03	-159	3.35	28.1/10.38
MW-21S	9.45	14.61	1.77	-342	0.64	19.5
MW-20S	7.31	17.72	3.6	-156	0.58	22
MW-19S	7.28	20.47	5.49	-162	0.53	19
MW-18S	7.78	16.74	1.72	-212	2.17	45
MW-17S	6.75	17.71	0.902	-106	4.11	17
MW-15D	6.95	16.09	4.98	-89	0.0	1.73
MW-15S	7.39	14.84	1.49	-148	0.88	4.1
MW-14S	7.15	16.62	0.779	-211	3.59	9.5
MW-13D	6.94	20.76	5.01	-179	0.87	3.9
MW-13S	7.20	14.18	0.818	-172	1.48	0.7/1.54
MW-12S	10.66	15.66	2.56	-394	1.1	21.4
MW-11D	7.18	16.23	3.90	-127	0.85	17.3
MW-11S	7.33	16.15	0.446	84	3.07	2.3/0.0
MW-10D	7.11	15.90	2.47	-100	0.00	8.9
MW-10S	7.32	15.83	1.38	-150	1.09	1.0
MW-9S	7.13	17.37	0.668	-174	0.66	26.3
MW-7S	7.38	17.67	0.615	-140	2.71	22
MW-6S	7.19	15.4	2.09	-144	1.12	19.9
MW-5	6.37	16.05	1.95	-187	1.87	21.3
MW-4	6.62	13.88	2.06	-195	2.25	9.5
MW-3	7.26	14.59	1.1	-353	0.56	0/0.65
MW-2S	9.30	14.27	0.447	-120	3.80	1.9
MW-1S	7.10	15.74	1.74	-118	1.20	38.0

Notes:
mg/L - milligrams per liter
mS/cm - millisiemens per centimeter
mv - millivolts
NTU - nephelometric turbidity units
ORP - Oxidation reduction potential
SU - standard units

Appendix D
USGS Groundwater Quality for Stratified Drift and Brunswick Aquifers

Appendix D. USGS Groundwater Quality in the Stratified Drift and Brunswick Aquifers

Appendix D-1. Major Metals Based on USGS Stratified Drift Search

		Calcium	Magnesium	Sodium	Potassium
site_no	sample_dt	p00915	p00925	p00930	p00935
15s	10d	12s	12s	12s	12s
4.04339E+14	5/4/2004	62.2	25.6	142	2.55
4.04339E+14	4/28/2008	35.2	14.9	100	1.3
4.04636E+14	6/23/2004	342	46.5	69.4	11.4
4.04636E+14	8/4/2008	253	33.6	52.6	11.5

Notes:
Water sample was filtered
Units are reported in milligrams per liter (mg/L)

Appendix D-2. Minor Metals Based on USGS Stratified Drift Search

		Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Thallium	Nickel	Silver	Zinc	Aluminium	Mercury
site_no	sample_dt	p01005	p01010	p01025	p01030	p01040	p01046	p01049	p01056	p01057	p01065	p01075	p01090	p01106	p71890
15s	10d	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s
404339074045401	5/4/2004	32	0.16	1.15	0.4	1.7	3	0.06	2780	0.02	24.5	0.1	43.5	21.6	0.01
404339074045401	4/28/2008	28	0.13	0.25	0.25	0.6	117	0.04	1340	0.02	12.4	0.05	15.5	16.6	0.005
404636074024701	6/23/2004	351	0.03	0.02	1.2	2.3	10200	0.04	4900	0.02	1.71	0.1	1.2	3.2	0.01
404636074024701	8/4/2008	306	0.02	0.02	1.4	0.5	625	0.04	4720	0.02	0.93	0.05	0.09	3.5	0.005

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-3. Major Non-Metals Based on USGS Stratified Drift Search

		pH	DO	DO	CO_2	Bicarbonate	Chloride	Sulfate	Fluoride	Silica	Alkalinity	Acid neutralizing capacity
			mg/L	% sat	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		unfiltered	unfiltered	unfiltered	unfiltered	filtered	filtered	filtered	filtered	filtered	filtered	unfiltered
site_no	sample_dt	p00191	p00300	p00301	p00405	p00453	p00940	p00945	p00950	p00955	p39086	p90410
15s	10d	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s
404339074045401	5/4/2004	0.00111	4.8	45	85	35	268	115	0.085	22.2	29	40
404339074045401	4/28/2008	0.00253	3	27	118	24	171	93.5	0.1	27.7	19	24
404636074024701	6/23/2004	0.00021	0.3	3	313	984	62.9	271	0.45	20.5	808	792
404636074024701	8/4/2008	0.00016	0.1	1	257	960	57.9	40.4	0.41	25	789	838

Notes:
% sat - percent saturation
CO_2 - carbon dioxide
DO - dissolved oxygen
mg/L - milligrams per liter
Water sample was filtered
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-4. Minor Non-Metals Based on USGS Stratified Drift Search

		Arsenic	Boron	Antimony	Selenium
site_no	sample_dt	p01000	p01020	p01095	p01145
15s	10d	12s	12s	12s	12s
404339074045401	38111	0.1	69	0.1	1.3
404339074045401	39566	0.25	52	0.07	0.41
404636074024701	38161	6.3	228	0.11	0.4
404636074024701	39664	0.65	248	0.13	0.12

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-5. Physical Parameters Based on USGS Stratified Drift Search

		Temperature Water °C	Temperature Air °C	Barometric pressure, mmHg	Flow rate, instantaneous, gpm	Color, water, filtered, platinum cobalt units	Specific conductance, water, unfiltered, µs/cm at 25°C	pH, water, unfiltered, field, SU	pH, water, unfiltered, laboratory, SU	Hardness, water, mg/L as $CaCO^3$	Noncarbonate hardness, water, unfiltered, field, mg/L as $CaCO^3$	Noncarbonate hardness, water, filtered, field, mg/L as $CaCO^3$	DTW level, below LSD, m	Turbidity, water, unfiltered, field, NTU	Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at	Dissolved solids dried at 180°C, water, filtered, mg/L	Dissolved solids, water, filtered, sum of constituents, mg/L	Dissolved solids, water, filtered, tons per acre-foot	DTW level, ftbls
site_no	sample_dt	p00010	p00020	p00025	p00059	p00080	p00095	p00400	p00403	p00900	p00902	p00904	p30210	p61028	p63676	p70300	p70301	p70303	p72019
15s	10d	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s
404825074063001	4/28/1959	12.8				3	6350	7.8		3300	640								
404834074061901	2/18/1971						8100	7.5		2400	2300								
404844074082501	4/28/2004	11	8.5	758	0.5		813	7.2	7.5	310		97	1.22	0.9		476	446	0.65	4
404844074082501	7/16/2008	19.5	32	764	0.15		831	6.8	7.1	270		34	0.655		16	480	457	0.65	2.15
404339074045401	5/4/2004	12.2	11	759	0.5		1300	6	6	260		230	2.93	0.5		776	689	1.06	9.6
404339074045401	4/28/2008	12.5	12.5	759	0.5		741	5.6	6.1	150		130	3.17		1.3	500	470	0.68	10.4
404636074024701	6/23/2004	13.3		760	0.18		2040	6.7	7	1000		240	2.58	1.7		1310	1330	1.78	8.47
404636074024701	8/4/2008	16.6	32	758	0.16		1640	6.8	7	770			2.63		1.1	1030	963	1.4	8.62

Notes:
°C - degrees celsius
µs/cm - microsiemens per centimeter
$CaCO^3$ - calcium carbonate
DTW - depth to water
ftbls - feet below land surface
gpm - gallons per minute
LSD - land surface datum
m - meters
mg/L - milligrams per liter
mmHg - millimeters mercury
nm - nanometer
NTU - nephelometric turbidity units
SU - standard units

Appendix D-6. Summary of Maximum and Minimum Concentrations in Major Metals Based on USGS Stratified Drift Search

	Calcium	Magnesium	Sodium	Potassium
Maximum	342	46.5	142	11.5
Minimum	35.2	14.9	52.6	1.3

Notes:
Water sample was filtered
Units are reported in milligrams per liter (mg/L)

Appendix D-7. Summary of Maximum and Minimum Concentrations in Minor Metals Based on USGS Stratified Drift Search

	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Thallium	Nickel	Silver	Zinc	Aluminium	Mercury
Maximum	351	0.16	1.15	1.4	2.3	10200	0.06	4900	0.02	24.5	0.1	43.5	21.6	0.01
Minimum	28	0.02	0.02	0.25	0.6	3	0.04	1340	0.02	0.93	0.05	1.2	3.2	0.005

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-8. Summary of Maximum and Minimum Concentrations in Major Non-Metals Based on USGS Stratified Drift Search

	pH	DO	DO	CO_2	Bicarbonate	Chloride	Sulfate	Fluoride	Silica	Alkalinity	Acid neutralizing capacity
		mg/L	% sat	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	unfiltered	unfiltered	unfiltered	unfiltered	filtered	filtered	filtered	filtered	filtered	filtered	unfiltered
Maximum	0.00253	4.8	45	313	984	268	271	0.45	27.7	808	838
Minimum	0.00016	0.1	1	85	24	57.9	40.4	0.085	20.5	19	24

Notes:
% sat - percent saturation
CO_2 - carbon dioxide
DO - dissolved oxygen
mg/L - milligrams per liter
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-9. Summary of Maximum and Minimum Concentrations in Minor Non-Metals Based on USGS Stratified Drift Search

	Arsenic	Boron	Antimony	Selenium
Maximum	6.3	248.00	1.29	2.51
Minimum	1.26	52.00	0.10	0.12

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-10. Summary of Maximum and Minimum Physical Parameters Based on USGS Stratified Drift Search

	Temperature Water °C	Temperature Air °C	Barometric pressure, mmHg	Flow rate, instantaneous, gpm	Color, water, filtered, platinum cobalt units	Specific conductance, water, unfiltered, µs/cm at 25°C	pH, water, unfiltered, field, SU	pH, water, unfiltered, laboratory, SU	Hardness, water, mg/L as $CaCO^3$	Noncarbonate hardness, water, unfiltered, field, mg/L as $CaCO^3$	Noncarbonate hardness, water, filtered, field, mg/L as $CaCO^3$	DTW level, below LSD, m	Turbidity, water, unfiltered, field, NTU	Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU	Dissolved solids dried at 180°C, water, filtered, mg/L	Dissolved solids, water, filtered, sum of constituents, mg/L	Dissolved solids, water, filtered, tons per acre-foot	DTW level, ftls	Specific conductance, water, unfiltered, laboratory, µs/cm at 25°C
Maximum	16.6	32	764	0.5	3	8100	7.8	7.5	3300	2300	240	3.17	1.7	16	1310	1330	1.78	10.4	1940
Minimum	11	8.5	758	0.15	3	741	5.6	6	150	640	34	0.655	0.6	1.1	476	446	0.65	2.15	787

Notes:
°C - degrees celsius
µs/cm - microsiemens per centimeter
$CaCO^3$ - calcium carbonate
DTW - depth to water
ftls - feet below land surface
gpm - gallons per minute
LSD - land surface datum
m - meters
mg/L - milligrams per liter
mmHg - millimeters mercury
nm - nanometer
NTU - nephelometric turbidity units
SU - standard units

Appendix D-11. Major Metals Based on USGS Brunswick Wide Search

		Calcium	Magnesium	Sodium	Potassium
site_no	sample_dt	p00915	p00925	p00930	p00935
15s	10d	12s	12s	12s	12s
404353074080001	5/10/1961	542	133		
404353074080001	5/2/1968	620	185	145	7.5
404713074033601	4/3/1969	62	6.4	11	1.6
404717074033501	4/3/1969	110	12	19	2.5
404819074063901	9/13/1968	330	43	47	1.1
404822074072201	8/24/1989	65	17	12	2.7
404829074072201	8/24/1989	77	18	14	2.2
404840074022901	8/30/1989	130	29	51	4
404844074065101	8/23/1989	100	9.5	18	1.1
404844074065101	9/6/2001	103	9.8	16.2	1.18
404332074104201	9/9/2003	185	14.6	147	6.86
404332074104201	4/22/2008	157	15.4	156	6.95

Notes:
Water sample was filtered
Units are reported in milligrams per liter

Appendix D-12. Minor Metals Based on USGS Brunswick Wide Search

		Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Molybdenum	Nickel	Silver	Strontium	Vanadium	Zinc	Aluminum	Lithium	Mercury
site_no	sample_dt	p01005	p01010	p01025	p01030	p01035	p01040	p01046	p01049	p01056	p01060	p01065	p01075	p01080	p01085	p01090	p01106	p01130	p71890
15s	10d	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s
404353074080001	5/2/1968							1200		750									
404713074033601	4/3/1969							70		500									
404717074033501	4/3/1969							0		560									
404819074063901	9/13/1968			0.5	0.5		0.5	32	2.5	11						9	5		0.05
404822074072201	8/24/1989	110	0.25	0.5	2.5	1.5	5	6	5	0.5	5	5	0.5	3700	23	22	5	14	
404829074072201	8/24/1989	77	0.25	0.5	2.5	1.5	5	8	20	1	5	5	2	3500	18	62	5	13	
404840074022901	8/30/1989	380	0.25	1	2.5	1.5	5	3700	5	75	5	5	2	2500	3	290	5	18	
404844074065101	8/23/1989	110	0.25	0.5	2.5	1.5	5	5	5	0.5	5	5	0.5	150	3	82	10	11	
404844074065101	9/6/2001							5		1.5									
404332074104201	9/9/2003	87	0.03	0.04	0.4		2.6	4	0.04	73.1		3.12	0.1			2.2	1.1		0.009
404332074104201	4/22/2008	85	0.005	0.04	0.06		0.75	4	0.04	0.3		0.99	0.05			0.9	1.9		0.005

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)

Appendix D-13. Major Non-Metals Based on USGS Brunswick Search

		pH	DO	DO	CO_2	Acid neutralizing capacity as $CaCO^3$	Bicarbonate	Carbonate	Chloride	Sulfate	Fluoride	Silica	Alkalinity	Acid neutralizing capacity as $CaCO^3$	Carbonate	Bicarbonate	Carbonate	Bicarbonate
		mg/L	mg/L	% sat	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		unfiltered	unfiltered	unfiltered	unfiltered	unfiltered	unfiltered	unfiltered	filtered	filtered	filtered	filtered	filtered	unfiltered	unfiltered	unfiltered	unfiltered	unfiltered
site_no	sample_dt	p00191	p00300	p00301	p00405	p00410	p00440	p00445	p00940	p00945	p00950	p00955	p39086	p90410	p99430	p99440	p99445	p00453
15s	10d	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s
404352074081101	3/14/1966	0.00007	0.3		53	377												
404353074080001	5/10/1961					113	138	0	1140	414								
404353074080001	5/2/1968	0.00001			4		200	0	1400	517	0.1	21						
404614074082001	3/14/1966	0.00003	6.8		10	183												
404622074111001	3/18/1966	0.00001			3.6	173												
404713074033601	4/3/1969	0.00001			1.5		116	0	18	90	0.2	26						
404717074033501	4/3/1969	0.00001			2.4		239	0	50	106	0.1	23						
404717074033501	3/13/1966	0.00011	0.6															
404819074063901	3/13/1966	0.00003	2.3		5	93												
404819074063901	9/13/1968	0.00004	2.5	24	6.3	85			75	950	0.1	34		85	81	99	0.5	
404819074063901	1/10/1969	0.00006	3.1															
404822074072201	8/24/1969	0.00003	3		6.6	136			59	33	0.1	19		120				
404829074072201	8/24/1969	0.00003	3.3		9.5	148			60	36	0.1	21		152				
404840074022901	8/30/1969	0.00001	0.1	0	1.7	60			340	13	0.1	16		49				
404844074065101	8/23/1969	0.00005	5.4		18	204			46	38	0.05	23		206				
404844074065101	9/6/2001	0.00005	4.6	46	20				74.2	30	0.1	23	220	194				
404332074104201	9/9/2003	0.00008	1.6	17	37				395	71.7	0.085	16.4	203	233				247
404332074104201	4/22/2008	0.00012	1	10	53				361	85.2	0.06	16.1	212	224				258

Notes:
% sat - percent saturation
$CaCO^3$ - calcium carbonate
CO_2 - carbon dioxide
DO - dissolved oxygen
mg/L - milligrams per liter

Appendix D-14. Minor Non-Metals Based on USGS Brunswick Wide Search

		Arsenic	Boron	Antimony	Selenium
site_no	sample_dt	p01000	p01022	p01095	p01145
15s	10d	12s	12s	12s	12s
404819074063901	9/13/1968	5			
404822074072201	8/24/1969	7			
404829074072201	8/24/1969	2			
404840074022901	8/30/1969	5			
404844074065101	8/23/1969	0.05			
404844074065101	9/6/2001	0.5	34 [1]		
404332074104201	9/9/2003	0.2	65	0.15	3.1
404332074104201	4/22/2008	0.39	69	0.07	2.8

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
½ method detection limit (MDL) value was used for non detect concentrations.

(1) - Water sample was unfiltered

Appendix D-15. Physical Parameters Based on USGS Brunswick Wide Search

		Temperature Water °C	Temperature Air °C	Barometric pressure, mmHg	Flow rate, instantaneous, gpm	Turbidity, water, unfiltered, NTU	Color, water, filtered, platinum cobalt units	ORP, reference electrode not specified, mv	Specific conductance, water, unfiltered, µs/cm at 25°C	pH, water, unfiltered, field, SU	pH, water, unfiltered, laboratory, SU	Hardness, water, mg/L as $CaCO^3$	Noncarbonate hardness, water, unfiltered, field, mg/L as $CaCO^3$	Noncarbonate hardness, water, filtered, field, mg/L as $CaCO^3$	Dissolved solids dried at 180°C, water, filtered, mg/L	Dissolved solids, water, filtered, sum of constituents, mg/L	Dissolved solids, water, filtered, tons per acre-foot	Specific conductance, water, unfiltered, laboratory, µs/cm at 25°C	DTW level, below LSD, m
site_no	sample_dt	p00010	p00020	p00025	p00059	p00076	p00080	p00090	p00095	p00400	p00403	p00900	p00902	p00904	p70300	p70301	p70303	p90095	p30210
15s	10d	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s	12s
404352074081101	3/14/1986	16						0.1	4000	7.1									
404353074080001	5/10/1961											1900	1800						
404353074080001	5/2/1968						20		5100	7.9		2300	2100		4880	2990	6.64		
404614074082201	3/14/1986	14.5			120				705	7.5									
404622074111001	3/18/1986	10.3							900	8									
404713074033601	4/3/1969	12					3		427	8.1		180	86		282	274	0.38		
404717074033501	4/3/1969	13					3		726	8.2		320	130		450	446	0.61		
404717074033501	3/13/1986	13.9						0.5		7									
404819074063901	3/13/1986	12.7						371	1850	7.6									
404819074063901	9/13/1988	12.5		760					1830	7.4	7.6	1000			1640	1540	2.23	1820	
404819074063901	1/10/1989	13							1940	7.2									
404822074072201	8/24/1989	13.9							520	7.6	7.7	240				319	0.43	526	
404829074072201	8/24/1989	13.9							711	7.5	7.8	270				347	0.47	598	
404840074022901	8/30/1989	11.6		760					1220	7.8	7.3	450				626	0.85	1280	
404844074065101	8/23/1989	15							660	7.3	7.7	290				388	0.53	645	
404844074065101	9/6/2001	15.6	33	767	1.6	0.03			707	7.3	7.4	300		77		411	0.56	692	
404332074104201	9/9/2003	15.3	21	770	0.5				1900	7.1	7.5	520		320	1170	992	1.59	1820	5.49
404332074104201	4/22/2008	14.3	14	770	0.5				1740	6.9	7.1	460		240	1080	950	1.47	1730	5.49

Notes:
$CaCO^3$ - calcium carbonate
gpm - gallons per minute
mg/L - milligrams per liter
mmHg - millimeters mercury
mv - millivolts
NTU - nephelometric turbidity units
ORP - Oxidation reduction potential
SU - standard units
µs/cm - microsiemens per centimeter

Appendix D-16. Summary of Maximum and Minimum Concentrations in Major Metals Based on USGS Brunswick Wide Search

	Calcium	Magnesium	Sodium	Potassium
Maximum	620	185	156	7.5
Minimum	62	6.4	11	1.1

Notes:
Water sample was filtered
Units are reported in milligrams per liter (mg/L)

Appendix D-17. Summary of Maximum and Minimum Concentrations in Minor Metals Based on USGS Brunswick Wide Search

	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Molybdenum	Nickel	Silver	Strontium	Vanadium	Zinc	Aluminum	Lithium	Mercury	Thallium
Maximum	380	0.25	0.5	2.5	1.5	5	3700	20	750	5	5	2	3700	23	290	5	18	0.05	0.02
Minimum	77	0.005	0.005	0.06	1.5	0.5	0	0.04	0.5	5	0.99	0.05	150	3	0.9	1.1	11	0.005	0.02

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-18. Summary of Maximum and Minimum Concentrations in Major Non-Metals Based on USGS Brunswick Wide Search

	pH	DO	DO	CO_2	Acid neutralizing capacity as $CaCO^3$	Bicarbonate	Carbonate	Chloride	Sulfate	Fluoride	Silica	Alkalinity	Acid neutralizing capacity as $CaCO^3$	Carbonate	Bicarbonate	Carbonate
		mg/L	% sat	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	unfiltered	unfiltered	unfiltered	unfiltered	unfiltered	unfiltered	unfiltered	filtered	filtered	filtered	filtered	filtered	unfiltered	unfiltered	unfiltered	unfiltered
Maximum	0.00012	6.8	46	53	377	258	0	1400	950	0.5	34	220	233	81	99	0.5
Minimum	0.00001	0.1	0	1.7	60	116	0	18	13	0.06	16	203	49	81	99	0.5

Notes:
% sat - percent saturation
CO_2 - carbon dioxide
$CaCO^3$ - calcium carbonate
DO - dissolved oxygen
mg/L - milligrams per liter
½ method detection limit (MDL) value was used for non detect concentrations.

Appendix D-19. Summary of Maximum and Minimum Concentrations in Minor Non-Metals Based on USGS Brunswick Wide Search

	Arsenic	Boron	Antimony	Selenium
Maximum	7	69	0.15	3.1
Minimum	0.2	34 [1]	0.07	2.8

Notes:
Water sample was filtered
Units are reported in micrograms per liter (µg/L)
[1] - Water sample was unfiltered

Appendix D-20. Summary of Maximum and Minimum Physical Parameters Based on USGS Brunswick Wide Search

	Temperature Water °C	Temperature Air °C	Barometric pressure, mmHg	Flow rate, instantaneous, gpm	Turbidity, water, unfiltered, NTU	Color, water, filtered, platinum cobalt units	ORP, reference electrode not specified, mv	Specific conductance, water, unfiltered, µs/cm at 25°C	pH, water, unfiltered, field, SU	pH, water, unfiltered, laboratory, SU	Hardness, water, mg/L as $CaCO^3$	Noncarbonate hardness, water, unfiltered, field, mg/L as $CaCO^3$	Noncarbonate hardness, water, filtered, field, mg/L as $CaCO^3$	Dissolved solids dried at 180°C, water, filtered, mg/L	Dissolved solids, water, filtered, sum of constituents, mg/L	Dissolved solids, water, filtered, tons per acre-foot	Specific conductance, water, unfiltered, laboratory, ms/cm at 25°C	DTW level, ftbls	DTW level, below LSD, m
Maximum	16	33	770	120	0.9	20	371	5100	8.2	7.8	2300	2100	77	4880	2990	6.64	1820	18	5.49
Minimum	10.3	14	760	0.5	0.03	3	0.1	427	6.9	7.1	180	86	77	282	274	0.38	526	18	5.49

Notes:
°C - degrees celsius
µs/cm - microsiemens per centimeter
$CaCO^3$ - calcium carbonate
gpm - gallons per minute
mg/L - milligrams per liter
mmHg - millimeters mercury
mv - millivolts
NTU - nephelometric turbidity units
ORP - Oxidation reduction potential
SU - standard units